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REVIEW OF FISH HANDLING TECHNIQUES IN HAWAII

By

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INTRODUCTION

The Hawaiian Islands, by virtue of their volcanic origin, have steep-sided bases which limit the shelf zone to a narrow band that surrounds each island. The geological formation of the islands is vitally important to fishing in Hawaiian waters, because unlike the continental shelf that characterizes most of the world's great fishing areas, these island shelves are narrow, poorly developed, and do not offer the marine environment conducive to high fishery yields.

Hawaii's existing commercial fisheries consist of an offshore segment for pelagic species such as tuna, billfish, wahoo, and mahimahi, and a nearshore one that concentrates on a variety of demersal and bathypelagic fish and shellfish. Of the 680+ species found in Hawaiian waters, only about 60-70, mostly occurring on the reefs and inshore areas, are commercially exploited. Many species occur only seasonally; the result is that Hawaii's fishermen are unable to supply the demand for fresh fish on a continuing basis.

Hawaii's per capita consumption of fish and shellfish in 1970-77 varied from 8.8 to 11.7 kg whereas the U.S. consumption rate varied between 5.2 and 5.9 kg or roughly twice the national average (Hudgins 1980). Many of the people living in Hawaii come from a wide variety of ethnic backgrounds including Hawaiian, part-Hawaiian, Caucasian, Japanese, Chinese, Filipino, Korean, Portuguese, and Samoan. This combination of high consumption rate and ethnic preferences for traditional fish dishes makes the consumers in Hawaii unique.

Fish is a luxury food that prosperous consumers in Hawaii could well afford, not a daily necessity as it is to many people living in other South

Pacific island communities (Manar 1969). Whether prices are high because of the existing market structure or because the fish industry operates in a manner to stifle competition has been the subject of several studies in the past few years (U.S. Department of Commerce 1971; Peterson 1973; Garrod and Chong 1978; Adams¹).

Whatever the real causes for the excessively high prices charged for fresh fish and fishery products in Hawaii, there is still a steady demand for fresh fish and the local fishermen go to great lengths to preserve their catch to satisfy this particular need. This paper reviews some of the methods used by local fishermen to bring their catches to the market in ocean-fresh condition.

THE RESOURCES

Hawaii's commercial fisheries, which have been described in general by Manar (1969) and Uchida (1979), can be divided into two major categories--the offshore, pelagic fisheries conducted by the larger vessels such as those used in tuna fishing and the inshore, benthopelagic, and demersal fisheries prosecuted by smaller crafts such as those engaged in mackerel purse seining, handline fishing, lobster and fish trapping, and crab netting.

¹M. F. Adams. 1981. Competition and market structure in the Hawaii fish industry. Southwest Fish. Cent. Admin. Rep. No. H-81-5, Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 20 p.

The Offshore Resource

The offshore fisheries is conducted in the open ocean in depths beyond 200 m where pole-and-line sampans harvest almost all the Hawaiian landings of skipjack tuna, Katsuwonus pelamis, and longline boats catch deep-swimming tunas including yellowfin tuna, Thunnus albacares, bigeye tuna, T. obesus, and albacore, T. alalunga; billfishes such as striped marlin, Tetrapturus audax, blue marlin, Makaira nigricans, black marlin, M. indica, swordfish, Xiphias gladius, shortbill spearfish, T. angustirostris, and sailfish, Istiophorus platypterus; and other species such as wahoo, Acanthocybium solandri, and mahimahi, Coryphaena hippurus.

A relative newcomer to the offshore fishing scene is the "ika-shibi" or night handline fishery for tuna (Yuen 1979) and to a lesser extent, the "palu-ahi" or "maki-dogu" fishery, which is essentially a daytime handline fishery. Also contributing to catches of offshore pelagic fishes are the trollers which in recent years have caught significant numbers of albacore in the North Pacific north of Midway Islands.

The Inshore Resource

The inshore fisheries in Hawaiian waters are for a wide variety of demersal and bathypelagic species which are caught by handline, traps, and nets. In the handline fishery, the major species include opakapaka, Pristipomoides filamentosus, kalekale, P. sieboldii, gindai, P. zonatus, ehū, Etelis carbunculus, onaga, E. coruscans, uku, Aprion virescens, kahala, Seriola dumerili, ulua, Caranx spp., weke, Parupeneus spp., and hapuupuu, Epinephelus quernus. The most important benthopelagic species is akule, Selar crumenophthalmus, which is second only to tuna and billfish in

total landings (Uchida 1978). Akule are commonly taken by three types of gear--bag net, handline, and gill net, which account for nearly two-thirds, 20 and 13% of the annual landings, respectively (Kazama 1977). Also of importance in the inshore fishery is the opelu, Decapterus macarellus, which is widely distributed in the tropics and is found in small schools just outside the breakers and off coral reefs. The gear used to catch opelu are the hoop net, which accounts for slightly more than half of the opelu landings, and handline, which produced roughly 45% of the catch.

HARVESTING

The offshore harvesting methods have been described in detail in several reports, for example, June (1950, 1951); Yoshida (1966); Yuen (1979); and Dotson (1980). Inshore fishing methods, for example, handline fishing and trapping, have never been adequately described for the commercial Hawaiian fishery. Kazama (1977) provided a detailed description of the fishing methods used for akule; for opelu, the reader is referred to Powell (1968).

Briefly, the handline gear, which consists of a 1,100-m length of 118-kg hard-braided nylon line to which a terminal rig is attached, is either hauled by hand or hydraulic gurdy. The terminal rig consists of a drop line, hook lines, hooks, and weight. Usually, four hooks are fished but the number may vary up to six or seven depending on personal preference. To each hook line, a recurved Hawaiian "oio" or "Tankichi" hook is attached, the size usually depending on the target species. For most bottom fish species, hook size No. 28 is most ideal. The weight used to take the line down to the bottom is usually about 1.4 kg but this may vary depending on the strength of the current.

For trapping, there is no set standard for traps with respect to size or shape. Some are rectangular, single-chambered, and have one or two entrances, either conical or oval. Others are half-moon shaped with a single entrance. Frames for the traps are usually of 0.9- or 1.3-cm reinforcing steel. All traps are covered with 2.5-cm chicken wire mesh. Traps may be baited with chopped fish or left unbaited; attractive objects such as white porcelain dishes are hung in unbaited traps as lures. Traps are pulled periodically and the fish removed. Hawaiian trap fishermen do not mark their traps with surface buoys as is commonly done in other parts of the world. Some use submerged buoys; others use no buoys at all. Experienced fishermen usually locate their traps by triangulating on prominent objects or landmarks along the shoreline.

HANDLING THE CATCH AT SEA

In pole-and-line fishing, when a tuna school breaks off from the stern of the vessel and is considered no longer fishable, the crew stows the catch immediately in baitwells that have been emptied of bait during fishing. The temperature of the seawater in the baitwell is lowered by adding crushed ice, the amount added depending on the size of the catch. On some vessels, those fish that are destined for the fresh fish market are given special handling. Each fish is individually stowed head down and crushed ice is packed into the spaces between the fish. This method of handling prevents damage that may occur if fish are simply stowed in the chilled seawater one on top of the other.

Upon return to port with the day's catch, the crew unloads by hand if the catch is small or if part of the catch is consigned to the fresh fish

market. Market fish are unloaded into galvanized metal cans and sorted according to size. After the market fish are unloaded and each can weighed, the crew uses a conveyor to unload the balance of the catch into trucks for sale to the cannery. At other ports, for example at Kaneohe Bay, the entire catch is unloaded by hand. Garrod and Chong (1978) have estimated that about 4,500 kg of skipjack tuna can be absorbed daily by Hawaii's fresh fish market. Annually, this amounts roughly to 1,650 metric tons.

When the catch is inadequately refrigerated, a condition known as honeycombing can occur (Otsu 1957). Honeycombed fish have pitted and cellular-like flesh. Studies by Frank et al. (1981) demonstrated that honeycombing occurred at an optimum temperature of 32.2°C and was even present when antibiotics were used to inhibit microbial activity and histamine formation. They also found that freshly caught skipjack tuna had tissue that was practically devoid of histamine; however, this compound formed readily when whole fish were left to incubate at higher temperatures. The optimum temperature for histamine production was 37.8°C. At still higher temperature (43.3°C), tissue deterioration was very extensive.

In the longline fishery, the entire catch is stowed over ice and covered with wet burlap. Among the steel-hulled longliners, a constant temperature can be maintained in the reefer using a Freon² refrigerant. On these boats, the catch is first packed in ice and then the temperature gradually lowered to maintain a constant -3.9°C.

²Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

In the "ika-shibi" and "palu-ahi" handline fishery, albacore, bigeye, and yellowfin tunas caught by the fishermen are simply chilled with ice to preserve their quality. This method of preserving quality, however, appears to be inadequate.

A condition known as burnt tuna has now become a major economic concern in the night "ika-shibi" fishery. The problem apparently is not new. Peterson (1973) documented the fact that longline-caught tunas are affected by a burnt condition from time to time. The fishermen believe that deterioration begins when a fish dies on the line before it is hauled aboard the longliner. This deterioration, which begins in the stomach of the fish, is described as a burn-like appearance. Cramer et al. (1981) described burnt tuna as "raw tuna which is paler and softer than normal." High-quality tuna, on the other hand, is translucent, red, and firm. Although edible, burnt tuna is undesirable for raw consumption as "sashimi" because the flesh has a poor texture, color, and tastes slightly sour. Cramer et al. determined that the burnt condition results from muscle cell degeneration which begins prior to the death of the fish. Degeneration proceeds more rapidly after death in burnt than in normal fish. The occurrence and severity of burnt tuna were found to be positively correlated with females, fighting time, and improper refrigeration.

Studies by Uda (1941) and Barrett and Hester (1964) have demonstrated that the body temperature of skipjack tuna and yellowfin tuna immediately after capture is generally higher than the seawater temperature. The relationship determined by Barrett and Hester indicates that length was of minor importance in the body temperature-sea temperature relationship for yellowfin tuna but for skipjack tuna, they found that small fish tended to

have lower body temperatures than larger ones. From their study, it appears that a 60-cm skipjack tuna caught in 28°C water may have an internal body temperature as high as 34.2°C.

Otsu (1957) has suggested that it is this high body temperature which causes the baitwell water to rise, particularly when large numbers of freshly caught fish are placed in it all at once.

The catches are chilled in ice on almost all handline fishing vessels, but on one vessel in the fleet part of the catch is chilled and frozen. Certain small species such as menpachi, Myripristis spp., kumu, Parupeneus porphyreus, weke, Upeneus arge, Mulloidichthys samoensis, and M. auriflamma, akule, opelu, snapper, and other reef fishes are never frozen because of the preference of ethnic groups living in Hawaii for fresh fish. This is not to say that there is no market for frozen fish. Species such as ulua, Caranx ignobilis, when they constitute a large part of the catch, may be frozen for later sale in the thawed state.

During the past 5-6 yr, a fishery for spiny lobster, Panulirus marginatus, caridean shrimps, Heterocarpus ensifer and H. laevigatus, and kona crab, Ranina ranina, has developed in waters of the Northwestern Hawaiian Islands (NWHI). Spiny lobster, which has become one of the mainstays of this NWHI fishery, was initially all brought back to port alive in the vessel's baitwell, but because of the limited market for live lobsters, most of the vessels nowadays process the lobsters at sea, keeping only the tails which are brined then frozen.

Caridean shrimps are a relatively new product on the Hawaiian market. National Marine Fisheries Service experiments at sea have shown that deterioration sets in rapidly in caridean shrimps and that quick processing

including removing the head, chilling, and freezing is essential to maintain high quality (Strusaker and Aasted 1974). Experimental packs by one vessel have included use of a combination of brine chilling and freezing to produce an acceptable pack.

Kona crab, another crustacean found in relatively good numbers at certain locations in the NWHI, has been targeted as a species for possible development. Traditionally, kona crab was usually sold live like most other species of crab caught in Hawaiian waters and sold locally; however, because of the distance between Honolulu and the crabbing grounds in the NWHI, attempts have been made to sell frozen crab. This approach to marketing kona crab is similar to what is being done with dungeness crab, Cancer magister, snow crab, Chionoecetes bairdi, and king crab, Paralithodes kamtschatica, all of which are imported into the State. One other species of crab that has only recently been sold in a frozen state is the white crab, Portunus sanguinolentus.

IMPORTS

In addition to dungeness, king, and snow crabs, Hawaii imports clams, lobsters, shrimps, chilled fish, frozen fish, cured fishery products, and fish pastes, balls, sticks, and roe from the Pacific Northwest, Alaska, New Hebrides, Philippines, Taiwan, Japan, Panama, Fiji, New Zealand, and Australia (Garrod and Chong 1978; Hudgins 1980). Foreign imports alone accounted for 54% of the total supply of fish, fishery products, and shellfish in Hawaii (Hudgins 1980).

FISH PROCESSING

Much of the processing of fish in Hawaii is done by the one existing tuna cannery that packs local skipjack tuna, and other imported frozen tuna species, such as yellowfin tuna and albacore. Locally caught skipjack tuna are also sold fresh, cured, or as bait.

Almost all the large tunas and billfishes are sold fresh; those that are considered surplus to the local market are shipped to lucrative markets in the continental United States and Japan.

Although a good proportion of the fish and shellfish landed in Hawaii are sold fresh, there is a growing trend toward marketing some of the local catches in a frozen state, for example, lobster tails, caridean shrimps, kona crab, and white crab. There is also a small market for cured fish: skipjack tuna, akule, and opelu are frequently sold in the cured state.

One of the last major processors of fish in Hawaii is the fish cake manufacturer. Whereas they relied heavily on locally caught billfish in former years, almost all the manufacturers now rely on imported Japanese "surimi," which is a semiprocessed wet fish protein prepared from Alaska pollock, Theragra chalcogramma. Billfishes and scrap fish are also ground and mixed with "surimi" whenever they can be obtained inexpensively and in large enough quantities. Smaller quantities of fish paste sold at the fresh fish market are usually obtained from locally caught awa, Chanos chanos, awaawa, Elops hawaiiensis, and oio, Albula vulpes.

LITERATURE CITED

Barrett, I., and F. J. Hester.

1964. Body temperature of yellowfin and skipjack tunas in relation to sea surface temperature. *Nature (Lond.)* 203:96-97.

Cramer, J. L., R. M. Nakamura, A. E. Dizon, and W. N. Ikehara.

1981. Burnt tuna: Conditions leading to rapid deterioration in the quality of raw tuna. *Mar. Fish. Rev.* 43(6):12-16.

Dotson, R. C.

1980. Fishing methods and equipment of the U.S. west coast albacore fleet. U.S. Dep. Commer., NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-8, 126 p.

Frank, H. A., D. H. Yoshinaga, and W. K. Nip.

1981. Histamine formation and honeycombing during decomposition of skipjack tuna, Katsuwonus pelamis, at elevated temperatures. *Mar. Fish. Rev.* 43(10):9-14.

Garrod, P. V., and K. C. Chong.

1978. The fresh fish market in Hawaii. Hawaii Agricultural Experiment Station, College of Tropical Agriculture, University of Hawaii, Departmental Paper 23, 24 p.

Hudgins, L. L.

1980. Per capita annual utilization and consumption of fish and shellfish in Hawaii, 1970-77. *Mar. Fish. Rev.* 42(2):16-20.

June, F. C.

1950. Preliminary fisheries survey of the Hawaiian-Line Islands area. Part I - The Hawaiian long-line fishery. *Commer. Fish. Rev.* 12(1):1-23.

June, F. C.

1951. Preliminary fisheries survey of the Hawaiian-Line Islands area.
Part III - The live-bait skipjack fishery of the Hawaiian Islands.
Commer. Fish. Rev. 13(2):1-18.

Kazama, T. K.

1977. The "akule" fishery of Hawaii. Paper presented to South
Pacific Commission, Ninth Regional Technical Meeting on Fisheries,
Noumea, New Caledonia, 24-28 January 1977. SPC Fish. 9/WP.20, 7 p.

Manar, T. A.

1969. Pacific fisheries. In F. E. Firth (editor), Encyclopedia of
marine resources, p. 477-483. Van Nostrand Reinhold Co., N.Y.

Otsu, T.

1957. Development of "honeycombing" in Hawaiian skipjack tuna.
Commer. Fish. Rev. 19(1):1-8.

Peterson, S. B.

1973. Decisions in a market: A study of the Honolulu fish auction.
Unpublished Ph.D. dissertation, Univ. Hawaii.

Powell, R.

1968. Hawaiian "opelu" hoop net fishing gear. South Pac. Comm.,
Noumea, New Caledonia, 10 p.

Struhsaker, P., and D. C. Aasted.

1974. Deepwater shrimp trapping in the Hawaiian Islands. Mar. Fish.
Rev. 36(10):24-30.

Uchida, R. N.

1978. The fish resources of the western central Pacific islands. FAO Fish. Circ. 712, 53 p.

1979. Current status of fisheries in the Hawaiian Islands. Paper presented to South Pacific Commission, Eleventh Regional Technical Meeting on Fisheries, Noumea, New Caledonia, 5-10 December 1979. SPC Fish. 11/WP.5, 13 p.

Uda, M.

1941. The body-temperature and the bodily features of "katuo" and "sanma." [In Jpn., Engl. summ.] Bull. Jpn. Soc. Sci. Fish. 9:231-236. (Engl. transl. by W. G. Van Campen, 1951, In U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 51:18-24.)

U.S. Department of Commerce, Bureau of Census.

1971. County business patterns: Hawaii. U.S. Govt. Print. Off.

Yoshida, H. O.

1966. Tuna fishing vessels, gear, and techniques in the Pacific Ocean. In T. A. Manar (editor), Proceedings of the Governor's Conference on Central Pacific Fishery Resources, State of Hawaii, p. 67-89.

Yuen, H. S. H.

1979. A night handline fishery for tunas in Hawaii. Mar. Fish. Rev. 41(8):7-14.



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SEAMOUNT TRAWL FISHERY
FOREIGN VESSEL OBSERVER REPORT, TAKACHIHO MARU
(MAY 3-17, 1982)

By

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The 1982 foreign trawl fishery for western Pacific seamount groundfish opened May 1, 1982. As in previous years, the trawling office of Nippon Suisan Kaisha, Ltd., in Tobata, Japan, notified the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service of their proposed schedule for trawling inside the U.S. Fishery Conservation Zone (FCZ) around Hawaii (see Table 1 and Figure 1). The first trawler which operated in Hawaii's FCZ in 1982 was the Takachiho Maru, a 3,600-gross ton independent stern trawler which normally fishes in the Gulf of Alaska, but which had been trawling the Emperor Seamounts, northwest of Midway Islands since February 1982 (see Appendix Table 1). I boarded the Takachiho Maru from a U.S. Navy tug at Midway on May 2 (CUT) and began 14 days of sampling pelagic armorhead and alfonsin at the Hancock Seamounts.

Table 1.--Area of operation.

Emperor Seamounts	Nippon Suisan designation	Position	
		Latitude N	Longitude E
Kinmei	"G" Bank	35°00'	171°45'
Milwaukee group	"F" Banks		
Yuryaku	"FC"	32°40'	172°15'
Kanmu	"FB"	32°15'	172°47'
So. Kanmu	"FA"	32°02'	173°06'
Colahan	"E" Bank	31°00'	175°55'
Unnamed	"D" Bank	30°26'	177°28'
<u>Fishery Conservation Zone</u>			
Northwest Hancock	"C" Bank	30°16'	178°42'
Southeast Hancock	"J" Bank	29°48'	179°04'
Southeast Hancock	"K" Bank	29°40'	179°20'

As in my previous experience aboard a Nippon Suisan trawler (see Southwest Fisheries Center Administrative Report H-81-9, Kitakami Maru), working and living conditions were very comfortable, due in large part to efforts by Mr. M. Toriai of Tobata in planning to meet the unique problems facing a foreign vessel observer. On the Takachiho Maru, Captain Ooshio and Chief Radio Officer Shibuya both spoke English very well, as did Third Officer Iwamoto, who was of great help with my sampling during the fishing period. Weighing baskets of fish was facilitated by the large factory space, and by having a separate set of scales away from the processing area. Also my sampling station was located next to the conveyor that moved the catch to the production line, so I was able to watch for unusual fishes without wading into the catch bins.

Although fishing this spring was somewhat more successful than during the period fished by the Kitakami Maru (August-September 1981), catch rates

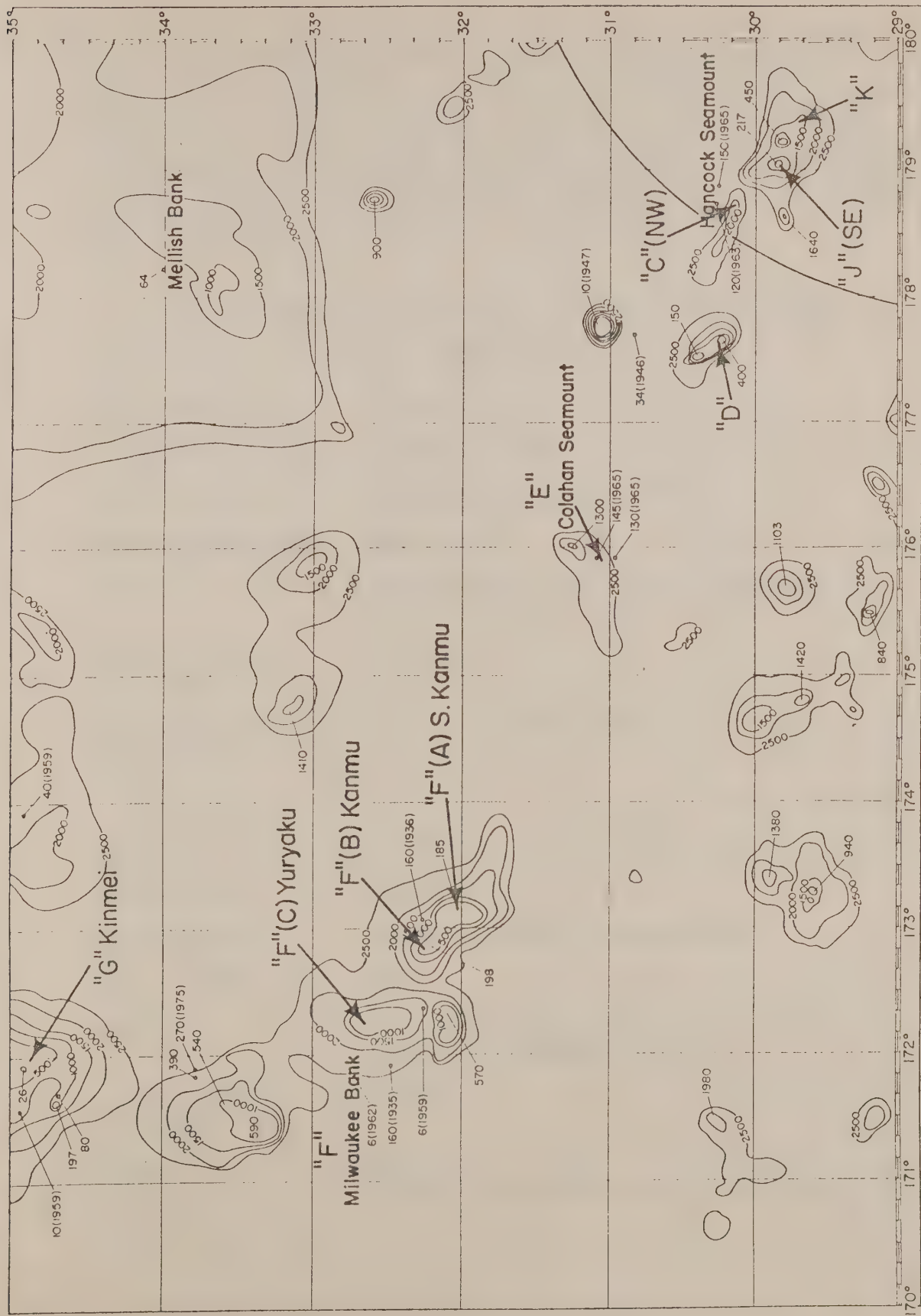


Figure 1.—Locations of seamounts and guyots northwest of the Northwestern Hawaiian Islands. Year of discovery is indicated for each guyot, and the 200-mile line is shown. Depths in fathoms.

were still disappointing in comparison with those of previous years. Nightly catches ranged from 7 to 50 metric tons (mt) of armorhead, averaging 20 mt early in the fishing period and dropping to 10 mt toward the end of the period. A total of 267.5 mt of all species were taken (Table 2) from a season's quota of 1,000 mt for Japan. The Takachiho Maru is of a size class which permits the use of fishmeal and oil extraction equipment, and this facility provides greater efficiency in the utilization of the resource than does the smaller Kitakami Maru which does not have such a capability.

Table 2.--Summary of total catch by species, Takachiho Maru.

<u>Target Species</u>	
Common names	Pelagic armorhead, boarfish
Japanese name	Kusakari tsubodai
Scientific name	<u>Pentaceros richardsoni</u> Smith
Federal Species Code ¹	200
Product	Headed, gutted, and frozen in 21-kg cases. Heads and viscera used for fishmeal and oil
Season's catch FCZ (to date)	243.5 mt
Total frozen product (to date)	143.7 mt = 6,844 cases
Common name	Alfonsin
Japanese name	Kinmedai
Scientific names	<u>Beryx splendens</u> , <u>B. decadactylus</u>
Federal Species Code ¹	201
Product	Dressed and frozen (lg) or whole frozen (sm) in 21-kg cases.
Season's catch FCZ (to date)	13.8 mt
Product (to date)	10.9 mt (round: 139 cases, dressed: 379 cases)

Incidental Species
(Federal Species Code 499)¹

<u>Common name</u>	<u>Scientific name</u>	<u>Product</u>
Mirror dory	<u>Zenopsis nebulosa</u>	Filletted, frozen (large fish only) meal/oil
(none)	<u>Hyperoglyphe japonica</u>	Dressed, frozen
(none)	Emmelichthyidae	Frozen whole
Season's catch FCZ: 10.2 mt (to date)		
Product		
Frozen:	8 mt (round: 337 cases, dressed: 36 cases, fillet: 5 cases)	
Oil:	14.4 mt	
Meal:	17.7 mt (= 590 bags)	

¹Federal Register 43(244):59301, Tuesday, December 19, 1978.

Essentially all fish were caught at night, between 8:00 p.m. and 6:00 a.m. local time, although an occasional trial haul in midday produced a few hundred kilograms. Day watches were usually spent maintaining and repairing equipment and chipping and painting the vessel. The weather at Hancock Seamounts was usually overcast and calm, with occasional sunny, breezy days.

Following a brief description of trawling and factory operations is a discussion of sampling methods and some observations on catch trends for this fishing period. Catches by species and area are tabulated in Table 3, catch per unit effort by species and area in Table 4, and biological sampling data are summarized in Table 5.

Table 3.--Trawl catch by species and area (in metric tons).

Species	Northwest Hancock Seamount	Southeast Hancock Seamount		All FCZ Banks
	"C" Bank	"J" Bank	"K" Bank	
Armorhead	63.8	157.2	22.5	243.5
Alfonsin	3.9	7.4	2.5	13.8
Others	4.1	5.6	0.5	10.2
Total	71.8	170.2	25.5	267.5

Table 4.--Catch per unit effort in kilograms per minute by area and species.

	Northwest Hancock Seamount	Southeast Hancock Seamount		All FCZ Banks
	"C" Bank	"J" Bank	"K" Bank	
Number of hauls	24	45	15	84
Total minutes trawling (includes turns off the seamount)	1,975	3,730	1,650	7,355
Armorhead				
Total catch (kg)	63,770	157,165	22,555	243,490
kg/min	32.3	42.1	13.7	33.1
Alfonsin				
Total catch (kg)	3,883	7,411	2,509	13,803
kg/min	2.0	2.0	1.5	1.9
Other species				
Total catch (kg)	4,147	5,624	436	10,207
kg/min	2.1	1.5	0.3	1.4
All species				
Total catch (kg)	71,800	170,200	25,500	267,500
kg/min	36.4	45.6	15.5	36.4

Table 5.--Summary of biological observations on armorheads and alfonsins.

	Northwest Hancock Seamount	Southeast Hancock Seamount			
	"C" Bank	"J" Bank	"K" Bank	All FCZ Banks	Range
<u>Armorheads--Total number of fish sampled: 1,684</u>					
Average fork length (mm)	305	304	304	304	271-410
Average weight (kg)	0.47	0.46	0.50	0.47	0.24-1.50
Sex ratio (% male:% female)				40:60	
Body type--essentially all lean type fish in FCZ					
<u>Alfonsins--Total number of fish sampled: 391</u>					
Average fork length (mm)	large 308 small 193	233	226	264	236
Average weight (kg)	large 0.70 small 0.27	0.50	0.42	0.52	0.48
Sex ratio (% male:% female) (large fish only)				75:25	

TRAWLING OPERATION

The gear and techniques used aboard the Takachiho Maru were essentially the same as on all previous seamount trawlers (see Appendix Figure 1). The otter boards are convex rectangular steel, 2.2 x 4.4 m. The footrope length is 60 m; vertical opening while in operation, 7 m, horizontal opening 20 m, with cod end mesh size 90 mm. The main trawl cable is 30-mm steel wire. The cable-out-to-depth (scope) ratio was 2.5. More detailed descriptions of trawling procedures are given in earlier reports.¹

The prospective site of the tow is first surveyed, using two wet paper recorders, a color video display, and side scan sonar. Then the net is deployed on approach to the site, and as many as five passes over the chosen site are made, bringing the doors up to the stern ports for each turn. During the haul a net recorder sends signals showing height of net opening, fish entering the net, as well as water temperature at fishing depth. Then, at a suitable time determined from the electronic displays, the net is retrieved at the end of a pass, and the catch dumped below deck

¹Observer reports on the central Pacific seamount trawl fishery:

Kazama, T. K. 1978. Seamount fishery, foreign vessel observer report, Ryuyo Maru No. 2, (April 22-June 3, 1978). Southwest Fish. Cent. Admin. Rep. 15H, 1978. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 6 p.

Evering, G. C., Jr. 1979. Seamount fishery, foreign vessel observer report, Aso Maru (May 27-July 10, 1979). Southwest Fish. Cent. Admin. Rep. H-79-14. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 10 p.

Everson, A. R. 1980. Seamount fishery, foreign vessel observer report, Kitakami Maru (August 9-October 4, 1980). Southwest Fish. Cent. Admin. Rep. H-80-15. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 13 p.

Everson, A. R. 1980. Seamount fishery, foreign vessel observer report, Aso Maru (September 24-30, 1980). Southwest Fish. Cent. Admin. Rep. H-80-16. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 10 p.

Shippen, N. T. 1981. Seamount fishery, foreign vessel observer report, Aso Maru (June 9-19, 1981). Southwest Fish. Cent. Admin. Rep. H-81-4. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 6 p.

Barnett, W. B. 1981. Seamount fishery, foreign vessel observer report, Kitakami Maru (August 15-October 1, 1981). Southwest Fish. Cent. Admin. Rep. H-81-9. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 12 p.

to the factory. A single site might provide one or more nights of steady fishing, or it might take all night to find any fish. The captain and navigational officers are very skillful in interpreting echo sounder displays and at negotiating the comparatively tiny fishing grounds in this area, even without the use of the loran. (Hancock Seamounts are in the shadow of transmission from the Kure Atoll loran station, so navigation is by Omega and a SATNAV plotter in addition to the bottom profilers.) Hangups were infrequent, but time consuming when they occurred. In one instance the headrope parted and the net recorder and several floats were lost. The recorder was recovered in good shape in a haul made 2 days later in the same area.

FACTORY OPERATION

The factory of the Takachiho Maru is a complex system of conveyors which sends the catch through two heading saws and into a washing vat. From there, more conveyors move the headed fish to sorting and packing tables, and the heads and trash fish into a grinder hopper above the fishmeal plant. The layout of the factory is essentially the same as that of the Aso Maru; its capacity is approximately 2 mt/h. At the packing tables, dressed fish are sorted and packed into 10.5 kg freezer trays by species and size. These trays are conveyed to a glaze sprinkler and placed in the flash freezer for about 5 h, after which the frozen blocks of fish are removed from the trays and wrapped in plastic. Two such blocks make up a 21-kg case of final product (= 23 kg gr. wt.) which is stored in the main fishholds. The fishmeal grinders and dryers produce 30-kg sacks of meal which are sold for agricultural use (animal feed and fertilizer), and the oil is kept in an 80-kl tank. Product recovery ratios from heads and viscera are about 16% for meal and 3-9% for oil, depending on the type of fish. Most of the incidental catch not mentioned in Table 2 was used for fishmeal and oil. A notable exception being the larger sharks and skates which were discarded. A collection of photographs of incidental species to this fishery is maintained at the Honolulu Laboratory, Foreign Vessel Observer Program.

SAMPLING METHODS

Because fishing was conducted only during the night, I was able to sample every significant haul and still get plenty of rest during the day. A rough idea (to within 1 mt) of the catch could be obtained by observing the cod end of the trawl when it was hauled aboard. I made a final estimate of the catch in the factory, based on experience at judging irregular heaps of fish in a bin of known dimensions. This figure was later checked against the figures kept on the vessel's logs.

Basket samples (15-30 kg each) were taken from the three or four largest hauls each night, and length measurements were obtained from conveyor fish for minor hauls. Randomness in sampling was assured by having the baskets filled early or later during processing of a particular haul, alternating with each sample. Each basket was then weighed (ship's platform scale) and sorted by species, and numbers of individuals of each species recorded. Composition of the catch is based upon the weight ratios obtained in this manner.

From the same sample, 30 armorhead were then individually measured, weighed, sexed, and graded as fat or lean body type. The average sizes and weights of fish, and sex ratios were estimated from these measurements and observations. Fork length was determined using a measuring board, and individual weights on hand held 1- or 3-kg scales. No otoliths were taken. Alfonsin were usually not present in any quantity in basket samples, so periodically 30 fish samples were taken from the conveyer for average fish lengths and weights. Large alfonsin were sexed (small fish normally have undeveloped gonads).

Incidental species were photographed, and notes were taken on stomach contents of armorheads and alfonsins and other general observations such as body type trends.

OBSERVATIONS

In general, the fish caught by the Takachiho Maru seemed to be of the same type as those caught by the Kitakami Maru last season, differing mainly in degree of gonad development. At this time of year ovaries are small and pink, the eggs becoming larger and more orange later in the summer. As on the Kitakami Maru, almost all armorhead caught within the FCZ were of the "lean" body type. There seemed to be less variation within this general type among the different seamounts; that is "C," "J," and "K" Banks all had armorhead of very similar size and weight, as opposed to the catch of the Kitakami Maru in which larger fish (and greater quantities) were found at "C" Bank. This year "J" Bank (Southeast Hancock) yielded more armorhead and markedly less alfonsin and other species than did "C" Bank (Northwest Hancock), a reversal of the late 1981 catch. "K" Bank (also on Southeast Hancock Seamount) showed some differences from "J" Bank, but as in previous years, the difficulties encountered in trawling at "K" Bank, because of its small size, precluded expending comparable fishing effort at that location.

Catch per unit of effort (trawling time) was about double that of last August and September; catch rates of "J" Bank were as much as 10 times higher than those obtained on the Kitakami Maru in 1981. As in 1981, catches were spotty and unpredictable. Sometimes a particular haul of several tons of fish was immediately preceded and followed by hauls of near zero catch. By far the most productive hauls were made between 3 and 5 a.m. local time, and catches fell sharply at daybreak. It would be interesting to learn the extent to which catch figures reflect actual amounts of fish present, and what role behavioral responses play in determining the catch of armorhead on a daily basis.

Alfonsin were not abundant, making up only 5% of the total catch inside the FCZ, although they are the object of a nearly single species fishery on seamounts outside the FCZ. All three U.S. banks fished had variable proportions of small and large alfonsins, with the greater volume seeming to comprise a mixture of large and small fish rather than exclusively small fish.

No precious coral was trawled on either of the FCZ seamounts.

ITINERARY
(CUT Dates)

May 2 - Honolulu (Hickam AFB) - Midway
Midway - Embarked Takachiho Maru
May 3 - Fishing began inside FCZ
May 17 - Fishing ceased inside FCZ
June 1 - Arrived Tobata, Kitakyushu, Japan
June 8 - Arrived Honolulu.

RECORDS

Scientist's log
Daily trawl haul form
Length/weight/sex log
Species composition from basket samples
Vessel sighting form
Time and attendance form
Radio report file
Photographs

Appendix Table 1.--Vessel and gear specifications and personnel,
Takachiho Maru, 1982.

Vessel

Permit No.	JA-82-0291-A
Length	96 m
Gross tonnage	3,609 mt
Net tonnage	1,968 mt
Width	16 m
Draft	9.8 m
Engine type	6 cylinder diesel
Fuel consumption	12 kl/day fishing, 14 kl/day running
Horsepower	3,900
Hull number	96150
Registration No.	F01-90
Company/owner	Nippon Suisan Kaisha
Vessel type	Independent stern trawler
Year launched	1965
Port of registry	Tokyo, Japan
Home port	Tobata, Kitakyushu, Japan
Radio call sign	JFBU

Gear

Net dimensions	See Appendix Figure 1
Door dimensions	See Appendix Figure 1
Main trawl winch	Electric 395 kW
Total wire on drum	2,000 m
Flash freezer capacity	2,560 trays = 1,280 cases
Processing speed	2 mt/h

Personnel

(53 total ship complement)

Prior experience in
seamount fishery

Captain	Mr. Masamichi Ooshio	1 year
Chief Radio Operator	Mr. Masaru Shibuya	None
Navigation Officers		None
Doctor		None
Engineers		None
Oilers		None
Galley		None
Deck and processing crew		None

NET DIMENSIONS AND CHARACTERISTICS

Type of Vessel Japanese Independent
Stern Trawler

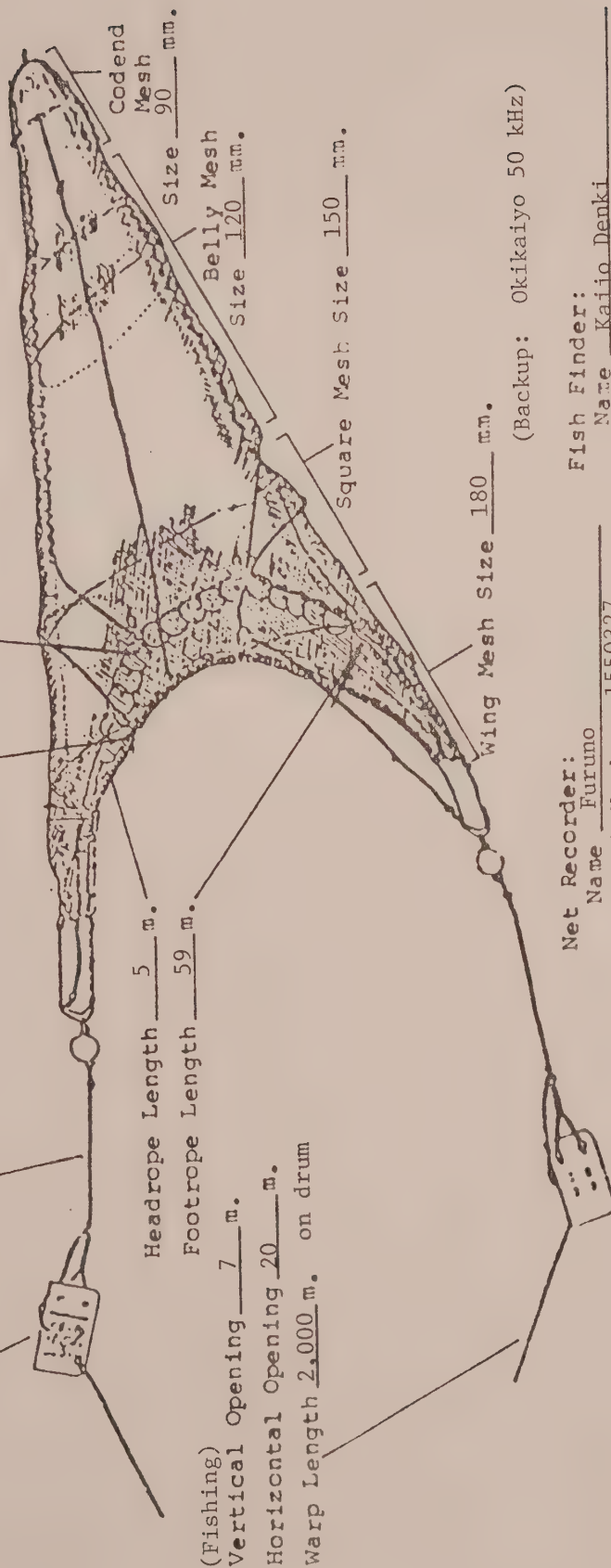
Observation Period May 1-17, 1982

Trawl Doors: Shape rectangular
Type steel-convex
Dimensions 2.2 m. x 4.4 m.
Weight 2,000 kg.

Dandyline Length 100 m.

Floats: Number 50
Size 30 cm diameter
Material plastic
Shape spherical

Bobbins: Number 33
Size 51 or 84 cm diameter
Material steel and rubber
Shape spherical



(Backup: Okikaiyo 50 kHz)

Net Recorder:
Name Furuno
Model Number 1550327
Frequency 50 kHz

Fish Finder:
Name Kaijo Denki
Model Number 2493 R-17J-5
Frequency 24 kHz
Paper Type - Wet x Dry
Speed of Advance _____

Appendix Figure 1.--Description of trawl gear used on the Takachiho Maru in this fishery.



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
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BACKGROUND INFORMATION ON THE NATIONAL MARINE FISHERIES SERVICE

HONOLULU LABORATORY LIBRARY

Hazel S. Nishimura
Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii 96812

LIBRARY

AUG 27 1982

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

July 1982

BACKGROUND OF ORGANIZATION

The establishment of the Southwest Fisheries Center, Honolulu Laboratory of the National Marine Fisheries Service (NMFS) in 1948 as the Pacific Oceanic Fishery Investigations (POFI) was authorized by the 80th Congress under Public Law 329. In 1958, with the passage of the Fish and Wildlife Act of 1956, POFI became the Hawaii Area of the Bureau of Commercial Fisheries (BCF) within the U.S. Department of the Interior. When the National Oceanic and Atmospheric Administration (NOAA) was created in the U.S. Department of Commerce in 1970, BCF became what it is today NMFS. The Honolulu Laboratory (HL) is one of four research laboratories in the Southwest Fisheries Center (SWFC). The other SWFC laboratories are the La Jolla Laboratory, which also serves as the center headquarters, and the Pacific Environmental Group in Monterey, and the Tiburon Laboratory. In addition to the SWFC, NMFS is composed of the Northwest and Alaska, the Northeast, and the Southeast Fisheries Centers, including 22 laboratories and facilities within the coastal borders of the United States.

ORGANIZATIONAL STRUCTURE

With a few exceptions each of the major laboratories has special libraries with either a librarian or a library technician in charge. Each library operates independently to service the needs of the various laboratory staffs. Since many of the laboratories are located adjacent to a large university offering graduate programs in marine science, the NMFS libraries serve that segment of students and faculty. The libraries serve other researchers as well as fishermen and state and local agencies interested in marine-related information.

The HL is located on the University of Hawaii (UH) campus and is within walking distance to Hamilton Library, the UH graduate library, with which mutual interlibrary loans, reference assistance, and computerized information retrieval services such as MEDLINE and Online Computer Library Center (OCLC) are maintained. Drawing from the University's entire library collection and from the special libraries of the Hawaiian Sugar Planters Association, the Bishop Museum, Hawaii State Department of Planning and Economic Development, and the East-West Center, the HL Library is able to fulfill about 90% of the requests locally. Assistance is also sought from the librarian at the SWFC Laboratory in La Jolla who has access to the resources of the Scripps Institution of Oceanography and the University of California San Diego Library as well as the entire University of California library system. It is rarely necessary to search beyond California although the library network in the United States makes it possible to procure almost any publication on interlibrary loan through OCLC.

The HL Library is organized for easy use. Journals and serially published documents which were formerly classified are now alphabetically arranged by title. Documents issued by government agencies are cross-referenced in the serial record file and shelved under country (e.g., Japan. Fisheries Agency). Books and monographs are catalogued by Library of Congress (LC) classification using the CIP data given in the majority of the new books. However, the LC classification has been modified to allow

for expansion to fit our special interests and requirements. Reprints are filed alphabetically by author in vertical file cabinets. Analytic cards are typed and filed for reprints as well as for articles of interest published in journals received by the HL Library. Analytic cards are stamped reprint file or periodical to indicate the location of the article.

TYPES OF INFORMATION

The bulk of fishery information appears in serials and journals such as the Fishery Bulletin, Transactions of the American Fisheries Society, Bulletin of the Japanese Society of Scientific Fisheries, Fishing News International, etc.

With the influx of highly specialized new journals in recent years, including Marine Environmental Research, Fisheries Research, Biological Oceanography, Journal Crustacean Biology, North American Journal of Fisheries Management, etc., libraries faced with reduced budgets and escalating costs of upkeeping the serials have to become more selective in purchasing new titles and deleting those of limited value and interest to the staff.

Books and monographs which are the other mainstay of the library collection require similar selectivity, although the HL Library procures whatever is required and requested by the staff. The HL's book purchases are handled through the University of Hawaii Bookstore.

The Library has a growing file of data reports on microfiche, National Technical Information Service (NTIS) reports dissertations and other miscellaneous items. It may be just a matter of time before the serials will have to be placed on microfiche.

Charts and maps of the Pacific are also requested frequently by the scientific staff. These are no longer kept in supply as before, but ordered as needed because of the continuous chart revisions.

Reprints fall within the responsibility of the Library. Except for printed abstracts, reprints are ordered for each article published by the scientific staff. These are placed in storage to fulfill requests received from other interested scientists on a first come basis. Due to the increasing cost of reprints, the standard order currently is 100 reprints for the Library and 50 for the authors. One set of the HL's reprints are bound annually for reference use and another set is forwarded to the Southwest Fisheries Center in La Jolla where the HL reprints are incorporated and bound with the entire Center reprints. Since many of the early publications of the 1950's are now out of print and the supply of reprints completely exhausted, the bound set serves as an invaluable annual record of publications.

Similarly the Library receives reprints from other laboratories. Some of these are received as bound volumes such as contributions of the Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Texas A&M Department of Oceanography, etc. However, most of the reprints are

single articles. Only those of interest to the staff and those that are not published in journals on subscription are retained and filed by author in the reprint collection.

The Library also has a strong collection of Japanese fisheries serials, particularly reports of the early Japanese fisheries surveys conducted in the late 1930's and the early 1940's in the western Pacific prior to World War II. These are on microfilm reels taken of the original Japanese documents obtained during the American occupation of Japan. Many of these articles were translated and published in the U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries series in 1950.

LIBRARY SERVICES

The Library's primary function is providing information and responding to staff needs on the literature searches. When embarking on a project, the investigator usually begins a literature search focusing basically on the specialized indices such as the Oceanic Abstracts, Aquatic Sciences and Fisheries Abstracts, Zoological Record, Biological Abstracts, Science Citation Index, etc. Depending on the subject matter, either a manual search is initiated and continued on the computer terminal using DIALOG or ORBIT. The manual search often provides subject awareness and additional clues in selecting key identifiers and descriptors for improved retrieval. The references may be either typed online if only a few are listed. If a long list of references is needed, an offline print may be requested which is mailed out the same evening from DIALOG information retrieval service at Lockheed's Palo Alto headquarters and received within 2-3 days (appendix). Cost varies with time online and the data base searched. Online search service is available only to the staff. Other users are referred to Hamilton Library.

References which are not in the Library's collection are requested on interlibrary loan locally from other libraries. The small percentage of requests which require borrowing outside of Hawaii are usually fulfilled by the SWFC Library in La Jolla. Although the HL rarely utilizes OCLC interlibrary loan services, the system provides information on the existence and availability of the requested document in any library in the United States affiliated with the OCLC network. All libraries possessing a particular title within a region is displayed on the terminal screen. A user need only to key the requested item online to receive the information. Status of the loan request (date mailed, plus any additional instructions on the loan) can be checked online as long as the transaction is active.

In-depth service such as specialized bibliographies and comprehensive literature searches are not generally available because of the lack of personnel. Instead, the requester is given assistance and instruction in doing his own searches of the subject field. This not only serves as a learning tool, but also benefits the requester in providing related information useful for the project. The HL Library devotes considerable time and effort in assisting undergraduate and graduate students, who come to the library for help, and teaching them on the use of the various reference tools and sources.

Services and tasks requiring immediate attention such as assisting outside users and staff take precedence. The daily but necessary housekeeping requirements of library operations such as recording serials, cataloging, circulating and shelving of books, binding volumes, etc., are carried out as time permits. An equivalent of 1 day a week is normally spent by the HL librarian at Hamilton Library to utilize the larger and more comprehensive reference resources there especially in the areas of economics, technology, law, etc., which are the subject fields seriously lacking in the HL Library collection. Frequent use is made of the Government Documents Collection which houses the established documents published by the United States Government and the United Nations (including the FAO publications). This collection is ordinarily for reference use only in the section, but exceptions are made for interlibrary loan limited to 1 week. This arrangement is also maintained with the Asian, the Hawaiian, and the Pacific Collections at Hamilton Library.

The HL Library serves as a focal point of exchange for fisheries information in the Pacific because of our geographic location. One of the important services is to function as a referral center. If the requested information is not available, referrals for contacts to the proper agencies are provided. More often than not, in the case of a request from a foreign country, the request for the information is usually initiated and obtained by us, then forwarded to the original requester. Realizing that many entities in the Pacific, especially the newly independent Pacific nations, lack the library resources readily available to us, the HL places an even greater effort to assist and provide the requested information whenever possible. All mail from Honolulu is sent by air.

INFORMATION DISSEMINATION AND DISTRIBUTION POLICY

It is fortunate that over 70% of the fisheries and related journals are received on an exchange basis with research institutions publishing their own series. The NMFS publishes Fishery Bulletin, NOAA Technical Report NMFS SSRF, NOAA Technical Report NMFS Circular, and Marine Fisheries Review (appendix) which are considered the basic established series. Arrangements for mailing and distributing are handled centrally through the Scientific Publications Staff located in Seattle, Wash. (Almand, J. David. 1974. Publications and Services of the National Marine Fisheries Service. Marine Fisheries Review 36(3):1-9. Also as MFR Paper 1039).

The HL issues a monthly report on research activities (appendix). This information is incorporated with the La Jolla Laboratory, Pacific Environmental Group, and Tiburon Laboratory reports in the Southwest Fisheries Center Monthly Report (appendix). Research highlights of each of the laboratories including the status of SWFC publications provide information on ongoing activities. The SWFC Report is distributed by the Center headquarters in La Jolla. Anyone interested may request copies. Also available for the asking is the Tuna Newsletter (appendix). The HL maintains a translation series (appendix) which is available on request.

There are no restrictions on the distribution of HL publications. The mailing list for the translation series is maintained in Honolulu; the SWFC

Monthly Reports and the Tuna Newsletter are mailed from La Jolla. The established NMFS publications such as Fishery Bulletin, Marine Fisheries Review, etc., are restricted to exchanges between institutions and libraries through NMFS Scientific Publications Unit in Seattle. Sales and subscriptions of the NMFS publications at a nominal cost to individuals may be made through the U.S. Superintendent of Documents, Government Printing Office, Washington, D.C. Other NMFS reports, including Administrative Reports and Contract and Grantee Reports, are available either as microfiche or paper copy from National Technical Information Service (NTIS) which, as an information service organization, is the central source for public sale of U.S. and foreign government-sponsored research, development and engineering reports (appendix). Cost is nominal, varying with the number of pages in the documents.

Individual copies, however, may be obtained without cost by writing to User Branch Services D822, Environmental Science Information Center, NOAA, Rockville, MD 20852. Authors are also quite willing to honor individual requests from their supply of reprints.

TRAINING PROGRAMS/FACILITIES OFFERED

The HL Library operates as a one-person library without any direct clerical assistance; the library facilities are available and open for use by anyone. No training programs are ordinarily provided; however, visitors passing through Honolulu are welcome to drop by for a visit.

APPENDIX

Publications listed in report:

1. DIALOG offline computer search on anchovy Engraulis mordax
2. Fishery Bulletin
3. NOAA Technial Report NMFS SSRF
4. NOAA Technial Report NMFS Circular
5. Marine Fisheries Review
6. HL Monthly Report
7. SWFC Monthly Report
8. Tuna Newsletter
9. HL Translation Series
10. Microfiche of Data Report from NTIS

Other NMFS publications:

1. Fishery Market News Reports (Terminal Island buff sheet)
2. Foreign Fishery Information Release
3. Southwest Fisheries Center Administrative Report
4. NOAA Technical Memorandum NMFS
5. Fish Meal and Oil Market Review
6. Shellfish Market Review
7. Food Fish Market Review
8. Fisheries of the United States
9. Fishery Statistics of the United States



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PRELIMINARY RESULTS OF A SURVEY OF
WHOLESALE FISH DEALERS IN HAWAII

1982

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

July 1982

PREFACE

The Fishery Management Research Task of the Southwest Fisheries Center Honolulu Laboratory initiated in 1980 a survey of the wholesale fish market in Hawaii. The survey consisted of a preliminary enumeration of total seafood volume followed by a monthly sampling of wholesale prices and quantities. The enumeration survey took place in mid-1980 and the monthly survey took place between October 1981 and May 1982. The survey was performed by SMS Research, Inc. (Contract No. 03-78-MO2-270).

This report presents preliminary results from the enumeration survey and is based on SMS Research's "Interim Status Report" which was submitted to the Laboratory in January 1982. The statements, findings, and conclusions herein are those of the contractor and do not necessarily reflect the official views of the National Marine Fisheries Service.

Data collected under this contract are held confidentially by the Southwest Fisheries Center Honolulu Laboratory, although researchers may use these data in an aggregated or otherwise desensitized format by contacting the Laboratory. The Southwest Fisheries Center Honolulu Laboratory intends to prepare an analytical report on the enumeration survey results later in 1982.

THE ENUMERATION SURVEY

Purpose of Survey

During development of the proposed survey of monthly prices and quantities of wholesale fish products in Hawaii, the need for an extensive preliminary survey was identified. This preliminary survey was initiated to serve as the basis for stratifying the firms involved and also to provide a general picture of the wholesale fish market industry in Hawaii.

Specific objectives of this enumeration survey included:

1. To define the actual population of firms which deal at the wholesale level of the fish marketing system in Hawaii. [The resulting list can be updated as changes occur within the industry, thus ensuring that any subsequent data collection activities will be based on the most accurate list available];
2. To provide information on the nature of the firms involved in this industry for a better understanding of the market;
3. To provide data on price and quantity estimates to allocate sample elements to sample strata for the primary monthly survey of wholesale fish products;
4. To provide data on classification variables other than price and quantity which could be used in constructing an optimum stratification system for the main data collection effort;
5. To provide a check on fielding and interviewing processes to improve fielding methods prior to the monthly surveys.

Sample

The universe of this study consisted of all firms that wholesale fish or fish products in the State of Hawaii. An initial list of firms was developed using the telephone directories of each county in the state, and it included firms ranging from small "mom and pop" operations to huge corporate ventures. The list was reviewed by the Southwest Fisheries Center Honolulu Laboratory and later updated by SMS Research staff to include new operations.

Survey Instrument

The survey instrument (appendix to this report) for the enumeration survey consisted of four major components: general firm data, revenue by type of fish products sold, source and distribution by type of fish products sold, and sales and purchase data.

General Firm Data

This section provided information about each fish dealer's business operations. Information was obtained on the type and size of each company, the number of years in business, and the principal functions of each, i.e., wholesaler, retailer, processor, or storage.

Analysis of Revenue by Type of Fish Products Sold

Five major fish products involved in this study are: 1) fresh fish; 2) frozen fish; 3) canned and bottled fish; 4) salted, dried, and smoked fish; and 5) fish cake. This section sought the percentage of total wholesale revenue accounted for by each of the product types.

Wholesalers were also asked to identify the percentage of total wholesale sales attributable to each species of fish. To make the enumeration survey manageable, the survey focused on 12 groups of fish species selected on the basis of catches reported to Hawaii Division of Aquatic Resources (HDAR) or the known importance in the marketplace.

Analysis of Source and Distribution by Type of Fish Product Sold

Each fish wholesaler was asked for source and distribution information for each type of product sold.

Source information.--Each wholesaler was asked to determine what percent of his total purchases was purchased locally, and of these local purchases, what percent was purchased directly from local fishers, from the auctions, and from other wholesalers.

The wholesaler was also asked to determine what percent of his total purchases was imported, either as mainland imports or foreign imports.

Distribution information.--Wholesale fish products in Hawaii are distributed in four ways: 1) to local retailers; 2) other wholesalers; 3) local processors; and 4) export. In this section, wholesalers were asked to determine the percentage of their wholesale sales going to each of the four distribution channels.

Sales and Purchase Data

All wholesalers were requested to provide information on total purchases (estimated) and total sales in last year's wholesale fish business. This information was recorded in pounds and dollar values for all fish and fish products, for fresh and frozen fish separately.

Data Collection

Pretest

Before conducting the actual enumeration, the survey instrument was pretested on several small fish dealers. The pretest was used to check the clarity of each question and to ensure the smooth administration of the interview in the field. No problems were noted during the pretest.

The fielding process.--The enumeration was conducted from July 14 to September 25, 1980. During that time, repeated interview attempts resulted in contact with 163 of the 185 sample firms; 44 of these were found to be ineligible, and interviews were completed with 106 of the remaining 119 firms (see Table 1). Interviews were conducted in several ways. Most frequently, an SMS interviewer would contact the owner or manager of the firm to make an appointment to conduct the interview. These interviews were usually held at the place of business during working hours. On several occasions, an interview was conducted while the respondent was actually cleaning fish.

In other instances when in-person interviews were not feasible, fish dealers were interviewed over the telephone.

After all of the interviews were completed, the data from the questionnaires were edited, coded, keypunched, and transferred to magnetic tape. The data on the tape were used for the construction of tables and were the basis for analysis. Tables 1 and 2 summarize the results of the field interviews.

Results

The enumeration sample consisted of the 106 firms which were identified as dealing to some degree at the wholesale level of the fish marketing system in Hawaii, and were willing to provide data for analysis. However, they do not represent the entire wholesale industry since 13 wholesale firms could not be contacted or did not want to participate in the enumeration survey.

Firm Structure

Most firms were organized as corporations (Table 3). This indicated some advantage of corporate structure over partnerships or proprietorships, such as limited tax liability or limited personal liability of owners.

Age of Firms

The industry appears to have a spread in ages of firms (Table 4). Most firms were recently established (less than 20 years in operation), but some have operated for over 60 years.

Type and Quantity of Employees

This industry is dominated by small firms (less than 50 full-time paid employees, Table 5). Firms with 76 to 200 employees were completely lacking. This study identified 2 large firms with more than 200 employees. A few firms had up to five non-paid full-time employees. These workers may represent family members in smaller operations.

Many firms used part-time, paid employees. Since 56% of firms used this type of employee, many smaller firms must be employing part-time help.

Function of Firms

The survey was limited to wholesale firms buying or selling at least some seafood. A surprising number (63 firms), however, also did some retailing (Table 6). Most wholesale firms did not participate in storage or processing activities.

The percentage of business at the wholesale level was relatively evenly distributed among firms (Table 7). Only 38 of 106 firms claimed all their business from wholesale activities.

Sources of wholesale revenue provided a different picture. Of 63 firms which had some dealings with fresh fish, 46% (29 firms) indicated that all wholesale revenues were from fresh fish. Few firms which dealt in fresh fish (12 firms) had less than 66% of wholesale business from fresh fish. This indicates that if a firm dealt with fresh fish, it was likely to derive a substantial (more than 67%) part of its wholesale revenues from it.

Frozen fish is a slightly different story. One third of the 63 firms which dealt with frozen fish dealt exclusively with that product. One hundred percent of their wholesale revenues came from frozen fish.

Only 17 firms dealt with canned and bottled fish to any degree. Of these firms, only one firm dealt with this product exclusively. A similar situation existed for salted, dried, or smoked fish. Only 26 firms dealt with these products to any degree, and only 3 firms dealt totally with these products. Only 13 firms dealt at all with fish cake. Three of these firms dealt solely with this product.

Quantity of Fish

Most firms (77%) purchased and sold between 10,000 and 999,999 pounds of fresh or frozen fish per year (Table 8). There were only 14 firms which handled over a million pounds.

Dollar Value of Fish

The situation for dollar amounts of the purchases and sales is similar to that for volume (Table 9). Most firms (65%) were in the \$10,000 to \$999,999 range. There were 14 purchasers and 16 sellers which handled over a million dollars in the year.

Species Groupings

Most groups of species comprise a variable portion of total wholesale business, for firms handling tuna, akule (bigeye scad), reef fish, crustaceans, mollusks, mahimahi (dolphin fish), and bottom fish (Table 10). Some groups of fish only provide a small percentage of wholesale revenues for any firm. Billfish, shark, and ono (wahoo) are fish that fall into this classification. The number of firms which handled these species ranged from 4 for shark to 48 for tuna. Only 16 firms out of 106 dealt with billfish, and billfish accounted for less than 34% of wholesale business for any of these firms.

Fresh Fish

If a firm dealt mostly with fresh fish (i.e., more than 67% of its wholesale revenue), then it was highly likely that the fish came from local sources (Table 11). In fact, 35 of 63 firms which dealt solely in fresh fish obtained them all from local sources. However, if fresh fish comprised less than 67% of wholesale sales, the firm could have obtained the fish from either local or import sources.

Further differentiation of sources of fresh fish revealed that the auctions were not the dominant source of fresh fish (Table 12). Only 27 of 57 firms purchasing locally used the auctions at all. Only six of these firms used the auctions for all of their fresh fish requirements. Local fishers were a substantial source of fresh fish. There were 41 firms which bought fresh fish directly from local fishers. Twenty one of these firms used them as the sole local source. Only 20 of 57 firms used other wholesalers as sources of fresh fish.

Only 27 firms imported fresh fish. Of these firms, 11 imported 100% of their purchases from the mainland. Also 6 of these firms imported 100% of fresh fish purchases from foreign sources. The rest used import sources to varying degrees.

Fresh fish was sold primarily to retail markets (Table 13). Of 63 firms, 41 obtained 67 to 100% of their wholesale revenue from sales to retailers. Five of these 63 firms did not sell to retailers. Sales to other wholesale firms appeared quite common. Thirty-eight of sixty-three firms sold to other wholesale firms. Five dealers sold solely to other wholesalers.

Processing of fresh fish is limited. Only 6 of 63 firms were engaged in processing. Exporting was also limited. Thirteen of sixty-three firms exported fresh fish. Most (11 of 13 firms) derived only 1 to 33% of their wholesale revenues from export.

Frozen Fish

If a firm dealt with frozen fish as a substantial part (more than 66%) of its wholesale revenue, it was highly likely that the fish came from import sources (Table 14). There were 48 of the 63 firms which dealt in frozen fish which had all of their wholesale revenue from import sources. Only 15 of 63 firms which dealt with frozen fish used local sources. If frozen fish comprised only a small percentage of wholesale revenues, the source could have been either local or import.

Further differentiation of sources of frozen fish revealed that for local sources, other wholesalers were the most important source (Table 15). Eleven of fifteen firms used other wholesalers exclusively as a source for frozen fish. The auctions were occasionally used, but local fishers were never used as a source for frozen fish. Import sources of frozen fish were split between mainland and foreign sources.

The destination of frozen fish was similar to that for fresh fish (Table 16). Thirty-two of sixty-three firms had all their wholesale revenue from sales to retailers. Six firms did not sell to retailers. Sales to other wholesalers were not uncommon (28 firms). Of these firms, six had all of their wholesale revenue derived from sales to other wholesalers. Only three firms sold to processors, and only two firms sold to export destinations. This indicates that most frozen fish, whether local or imported, is used in local consumption.

Canned and Bottled Fish

Only 15 firms had more than 5% of wholesale revenue from canned and bottled fish (Table 17). Most of these products were imported. Of 15 firms, 13 had 100% of wholesale revenue from canned and bottled fish. Two of these firms obtained their product solely from local sources; whereas 11 obtained their product solely from import sources.

Of the four firms which obtained canned and bottled fish from local sources (Table 18), one firm obtained all of its fish from local fishers. The other three obtained their fish from local wholesalers.

Thirteen of fifteen firms obtained their canned and bottled fish from import sources. Seven firms used foreign sources exclusively; whereas only two used mainland sources exclusively.

The destination of most of this product was the retail sector (Table 19). There were 7 firms that had 100% wholesale revenues from retail sales of canned and bottled fish. Only 1 of 15 firms did not participate in sales to retailers.

Seven firms sold this product to other wholesalers. One firm obtained all its wholesale revenue from sales to other wholesalers. No firm sold to processors, and only one firm exported canned and bottled fish.

Salted, Dried, and Smoked Fish

There were 22 firms that had more than 5% wholesale revenue from salted, dried, and smoked fish (Table 20). Most firms imported these products (17 of 22). Thirteen firms derived all of their revenues from imported salted, dried, and smoked fish. Six firms derived all of their revenues from local sources of this product.

Ten firms obtained this product from local sources which included local fishers, the auctions, and other wholesalers (Table 21). Of the 17 firms which did import, 11 firms bought from the mainland and 9 used foreign sources.

Salted, dried, and smoked fish were sold primarily to retail buyers (Table 22). Eleven firms obtained all their wholesale revenue from sales to retailers. Twelve of twenty-two firms sold to other wholesalers. No sales were made to processors or exporters.

Fish cake

Only six firms had more than 5% of wholesale revenue from fish cake (Table 23). Most fish cake (or its raw material) came from import sources. All six firms imported some fish cake, but only four firms used local sources of fish cake. All three local sources were used by these wholesalers (Table 24). Import sources were divided between mainland and foreign sources. Two firms obtained all their fish cake from the mainland; whereas one firm obtained all its fish cake from foreign sources.

Fish cake was sold primarily to the retail market (Table 25). All six firms sold to retailers, two firms sold to other wholesalers, and only one firm exported. No firms sold fish cake to processors.

Discussion

The enumeration survey showed that the wholesale fish marketing firms in Hawaii are not merely wholesalers of fish. There is some vertical integration of this marketing system since 60% of these firms are also retailers. There appears to be some specialization of firms in terms of products handled. Many firms handled either all fresh or all frozen products. However, this specialization is not apparent with regard to fish species. Few firms dealt solely with only one species or species group.

Most firms obtained their fresh fish from local sources, primarily local fishers. Most sold to retailers and some sold to wholesalers, processors, and the export market. Frozen fish, on the other hand, was primarily imported (from either the mainland or foreign countries). Sales were primarily to retailers.

The number of firms which dealt to any degree with canned and bottled fish, salted, dried, and smoked fish as well as fish cakes was small. These products are evidently of minor importance in the overall wholesale fish market.

Correlation Analysis

The primary purpose for the enumeration study was to identify key variables which could be used in stratification of the wholesale firms for sampling. To aid in this process, a correlation matrix was calculated for about half of the variables in the enumeration survey. The selection criteria for variables to be included were: 1) that the variable has a distribution of responses, as opposed to only one or two responses and 2) that the variable has a response from most firms questioned. Twenty-eight variables were included in the correlation matrix. Results of the correlation matrix are given in Table 26. Only coefficients with values larger than 0.20 or less than -0.20 are listed. Blank spaces indicate correlation coefficients within the 0.20 to -0.20 range.

The matrix was used as a basis for stratification. The rationale for selecting variables used in stratification was that each be highly correlated to other key variables in the matrix. At the primary level, since this study relates to price and quantity values, the key variable should be highly correlated to variables that describe price and quantities. The only variable which was significant with a relatively high (greater than 0.50) correlation coefficient for fresh as well as frozen sales and purchases (in dollars and pounds) was total sales in dollars (variable 27). No other variable was so highly correlated with so many key variables. Total sales in dollars was therefore selected as the primary variable to serve as a base for stratification.

A search was made for other key variables which were correlated with the different species groups, products, or forms. Percent of wholesale sales from tuna (variable 8) appeared to best fit the above criterion. However, its correlation with other variables was low. A consideration was whether or not further stratification by additional variables would be efficient and improve estimates of price and quantity values. Percent of wholesale sales from tuna had such low correlation coefficients with other variables that gains in efficiency did not appear to justify further stratification of the population in terms of this variable.

Table 1.--Disposition of all firms in the study.

	Oahu	Hawaii	Maui	Kauai	Total
Number of firms in sample	135	17	17	16	185
Firms unable to contact	16	0	2	4	22
Ineligible firms	31	2	6	5	44
Eligible firms	88	15	9	7	119
Completed interviews	76	14	9	7	106
Completion rate	86.4%	93.3%	100.0%	100.0%	89.1%

Table 2.--Distribution of completed interviews by county.

County	Number	Percentage
Oahu	76	71.7
Hawaii	14	13.2
Maui	9	8.5
Kauai	7	6.6
Total	106	100.0

Table 3.--Number of firms by firm structure.

Structure	Number of firms
Proprietorship	21
Partnership	8
Corporation	77
Total	106

Table 4.--Number of firms established by year.

Year	Number of firms
Before 1921	6
1921-1940	9
1941-1960	32
1961-1980	59
Total	106

Table 5.--Number of firms differentiated by type and number of employees.

Number of employees	Type of employees			
	Full-time		Part-time	
	Paid	Not paid	Paid	Not paid
0	5	93	47	104
1-5	50	11	53	2
6-25	37	2	4	0
26-75	12	0	1	0
76-200	0	0	0	0
More than 200	2	0	1	0
Total	106	106	106	106

Table 6.--Number of wholesale firms engaged in different activities.

Activity	Number of firms
Wholesale	106
Retail	63
Storage	15
Processing	27
Total	106

Table 7.--Number of firms differentiated by wholesale business and source of wholesale revenues.

Percentage of business	Wholesale business	Source of wholesale revenue				
		Fresh	Frozen	Canned bottled	Salted dried/smoked	Fish cake
1-33	20	5	28	6	18	9
34-66	13	7	8	6	4	1
67-99	35	22	6	4	1	0
100	38	29	21	1	3	3
Total	106	63	63	17	26	13

Table 8.--Number of firms differentiated by pounds of purchases and sales for specific products.

Pounds	Purchases			Sales		
	All fish	Fresh	Frozen	All fish	Fresh	Frozen
Less than 10,000	19	19	15	19	17	14
10,000 to 99,999	32	19	19	35	18	20
100,000 to 999,999	35	16	22	32	18	20
More than 100,000	13	4	3	14	4	3
Don't know	7	5	4	6	6	6
Total	106	63	63	106	63	63

Table 9.--Number of firms differentiated by dollar value of purchases and sales for specific products.

Dollars	Purchases			Sales		
	All fish	Fresh	Frozen	All fish	Fresh	Frozen
Less than \$10,000	16	16	15	13	12	12
\$10,000 to \$99,999	25	18	19	27	15	18
\$100,000 to \$999,999	41	16	22	44	21	20
More than \$1,000,000	14	6	3	16	8	8
Don't know	10	7	4	6	7	5
Total	106	63	63	106	63	63

Table 10.--Number of firms differentiated by percentage wholesale business from certain groups of species.

Percentage of business	Tuna	Akule	Reef fish	Crust- acean	Bill- fish	Opelu	Shark	Mollusk	Mahi- mahi	Ono	Bottom fish	Other
1-33	13	12	16	17	16	11	4	18	31	22	26	23
34-66	14	3	6	6	0	0	0	7	7	2	10	11
67-99	16	2	0	7	0	1	0	0	4	0	4	14
100	4	1	1	4	0	0	0	1	1	0	3	2
Don't know	1	0	0	0	0	0	0	0	0	0	0	0
Total	48	18	23	34	16	12	4	26	43	24	43	40

Table 11.--Number of firms dealing in fresh fish differentiated by source of wholesale revenue. (Base = 63 firms)

Percentage of wholesale revenue	Source	
	Local	Import
1-33	4	15
34-66	3	1
67-99	15	4
100	35	6
Don't know	0	1
Total	57	27

Table 12.--Number of firms dealing in fresh fish differentiated by percentage of purchases from specific sources. (Base = 63 firms)

Percentage of purchases	Local sources			Import sources	
	Fishers	Auctions	Wholesale	Mainland	Foreign
1-33	10	6	10	2	5
34-66	7	9	2	2	1
67-99	3	6	3	5	3
100	21	6	5	11	6
Don't know	0	0	0	1	1
Total	32	27	20	21	16

Table 13.--Number of firms dealing in fresh fish differentiated by percentage of wholesale sales to specific destinations. (Base = 63 firms)

Percentage of purchases	Destinations			
	Retail	Wholesale	Processing	Export
1-33	9	20	5	11
34-66	8	8	0	1
67-99	20	5	1	1
100	21	5	0	0
Don't know	21	5	0	0
Total	58	38	6	13

Table 14.--Number of firms dealing in frozen fish differentiated by source of wholesale revenue. (Base = 63 firms)

Percentage of wholesale revenue	Source	
	Local	Import
1-33	6	2
34-66	2	2
67-99	2	6
100	5	48
Total	15	58

Table 15.--Number of firms dealing in frozen fish differentiated by percentage of purchases from specific sources. (Base = 63 firms)

Percentage of purchases	Local sources			Import sources	
	Fishers	Auctions	Wholesale	Mainland	Foreign
1-33	0	1	0	10	8
34-66	0	9	0	10	10
67-99	0	0	1	8	10
100	0	3	11	18	12
Total	0	4	12	46	40

Table 16.--Number of firms dealing in frozen fish differentiated by percentage of wholesale sales to specific destinations. (Base = 63 firms)

Percentage of purchases	Destinations			
	Retail	Wholesale	Processing	Export
1-33	4	14	2	2
34-66	6	6	1	0
67-99	13	2	0	0
100	32	6	0	0
Don't know	2	0	0	0
Total	57	28	3	2

Table 17.--Number of firms having more than 5% of wholesale revenue from canned and bottled fish differentiated by source of wholesale revenue. (Base = 15 firms)

Percentage of wholesale revenue	Source	
	Local	Import
1-33	1	0
34-66	1	1
67-99	0	1
100	2	11
Total	4	13

Table 18.--Number of firms having more than 5% of wholesale revenue from canned and bottled fish differentiated by percentage of purchases from specific sources. (Base = 63 firms)

Percentage of purchases	Local sources			Import sources	
	Fishers	Auctions	Wholesale	Mainland	Foreign
1-33	0	0	0	2	0
34-66	0	0	0	2	2
67-99	0	0	0	0	2
100	1	0	3	2	7
Total	1	0	3	6	11

Table 19.--Number of firms having more than 5% of wholesale revenue from canned and bottled fish differentiated by percentage of wholesale sales to specific destinations. (Base = 63 firms)

Percentage of wholesales revenue	Destinations			
	Retail	Wholesale	Processing	Export
1-33	2	3	0	1
34-66	1	1	0	0
67-99	4	2	0	0
100	7	5	0	0
Total	14	7	0	1

Table 20.--Number of firms having more than 5% of wholesale revenue from salted, dried, and smoked fish differentiated by source of wholesale revenue. (Base = 22 firms)

Percentage of wholesale revenue	Source	
	Local	Import
1-33	3	1
34-66	0	0
67-99	1	3
100	6	13
Total	10	17

Table 21.--Number of firms having more than 5% of wholesale revenue from salted, dried, and smoked fish differentiated by percentage of purchases from specific sources. (Base = 22 firms)

Percentage of purchases	Local sources			Import sources	
	Fishers	Auctions	Wholesale	Mainland	Foreign
1-33	1	0	1	3	0
34-66	2	3	2	0	0
67-99	0	0	0	0	3
100	2	0	5	8	6
Total	5	3	8	11	9

Table 22.--Number of firms having more than 5% of wholesale revenue from salted, dried, and smoked fish differentiated by percentage of wholesale sales to specific destinations. (Base = 22 firms)

Percentage of purchases	Destinations			
	Retail	Wholesale	Processing	Export
1-33	0	4	0	0
34-66	7	7	0	0
67-99	4	0	0	0
100	11	1	0	0
Total	22	12	0	0

Table 23.--Number of firms having more than 5% of wholesale revenue from fish cake differentiated by source of wholesale revenue. (Base = 6 firms)

Percentage of wholesale revenue	Source	
	Local	Import
1-33	3	0
34-66	1	1
67-99	0	3
100	0	2
Total	4	6

Table 24.--Number of firms having more than 5% of wholesale revenue from fish cake differentiated by percentage of purchases from specific sources. (Base = 6 firms)

Percentage of purchases	Local sources			Import sources	
	Fishers	Auctions	Wholesale	Mainland	Foreign
1-33	0	0	0	2	0
34-66	0	1	1	1	1
67-99	0	0	0	0	2
100	2	1	0	2	1
Total	2	2	1	5	4

Table 25.--Number of firms having more than 5% of wholesale revenue from fish cake differentiated by percentage of wholesale sales to specific destinations. (Base = 6 firms)

Percentage of purchases	Destinations			
	Retail	Wholesale	Processing	Export
1-33	0	1	0	1
34-66	1	1	0	0
67-99	2	0	0	0
100	3	0	0	0
Total	6	2	0	1

Table 26.--Correlation coefficient matrix of key variables from the enumeration survey of wholesale fish dealers.

(Correlation coefficients listed for correlations outside -0.20 to 0.20 range.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
1						-21		21												85	78					85						
2					60	-34	36	-20	-23										25													
3									-19																							
4								-21				-29									-20	-20					-21		-21			
5		60				-43	31	-22	-21	-26	27				19	20		-20	21						20		26				42	
6	-21	-34			-43		-68	36	24	30					-28	-40	32		-42			28	23	-22	-23			30	25	-21	-25	
7		36			31	-68		-40		-19	28					54	-21		22					35	35					35	37	
8	21	-20		-21	-22	36	-40				-33				-21	-27	21	-21	-32	22	23	31	26			22		33	26			
9		-23	-19		-21	24																										
10					-26	30	-19																									
11					27		28	-33										-21														
12				-29																												
13																																
14																27																
15					19	-28		-21						27																		
16					20	-40	54	-27																							28	
17						32	-21	21																								
18					-20			-21			-21																					
19		25			21	-42	22	-32																								
20	85			-20				22													92					100	85					
21	78			-20				23													92		32	37	28	13	92	98	30	36	28	33
22						28		31													12		87	21			61	96	87	21		
23						23		26													37	87					69	84	99			
24						-22	35														28	21			85		64	21		100	85	
25					20	-23	35														33				85		71			85	99	
26	85			-21				22													100	92					84					
27					26																85	98	61	69	64	71	84		59	70	64	73
28				-21		30		33														30	96	84	21			59		86	21	
29						25		26														36	87	99				70	86			
30						-21	35														28	21		100	85		64	21			86	
31					22	-25	37									28					33				85	99		73			86	

1 Number of full-time employees.

2 Engage in retail sales?

3 Engage in storage?

4 Engage in processing?

5 Percent business wholesale.

6 Percent wholesale revenue from fresh fish sales.

7 Percent revenue from frozen fish sales.

8 Percent wholesale revenue from tuna sales.

9 Percent wholesale revenue from skule sales.

10 Percent wholesale revenue from reef fish sales.

11 Percent wholesale revenue from crustacean sales.

12 Percent wholesale revenue from billfish sales.

13 Percent wholesale revenue from opelu sales.

14 Percent wholesale revenue from shark sales.

15 Percent wholesale revenue from mollusks sales.

16 Percent wholesale revenue from mahimahi sales.

17 Percent wholesale revenue from ono sales.

18 Percent wholesale revenue from bottom fish sales.

19 Percent wholesale revenue from other fish sales.

20 Total purchases--pounds.

21 Total purchases--dollars.

22 Fresh purchases--pounds.

23 Fresh purchases--dollars.

24 Frozen purchases--pounds.

25 Frozen purchases--dollars.

26 Total sales--pounds.

27 Total sales--dollars.

28 Fresh sales--pounds.

29 Fresh sales--dollars.

30 Frozen sales--pounds.

31 Frozen sales--dollars.

APPENDIX

ENUMERATION SURVEY INSTRUMENT

NOAA FISH STUDY
PRELIMINARY ENUMERATION SURVEY

SMS Research
July, 1980

Interviewer: _____

Date: _____

Name of Firm: _____ I.D. # _____

Address: _____

Contact Person: _____ Title: _____

1. What is the structure of your firm? (CIRCLE ONE)

proprietorship 1
partnership 2
corporation 3
association 4
other _____ 5
don't know/refused 9

2. How many employees do you have who are:

Paid: full-time (over 30 hrs./week) _____
part-time _____
Non-paid: full-time _____
part-time _____

3. What year did your firm start operating in Hawaii? _____

4a. What are the functions of your firm? (READ LIST AND CIRCLE ALL THAT APPLY.)

	<u>Yes</u>	<u>No</u>
wholesale sales	1	2
retail sales	1	2
storage	1	2
processing	1	2

4b. What percentage of your total business is wholesale? _____%

If "wholesale sales" in #4a is marked "2," and if #4b is marked "0%," THANK RESPONDENT AND TERMINATE

5. What percentage of last year's wholesale revenue came from:

fresh fish	_____ %
frozen fish	_____ %
canned and bottled fish	_____ %
salted, dried and smoked fish	_____ %
fishcake	_____ %
TOTAL	100 %

Now, I have a few questions about the SALTED, DRIED AND SMOKED FISH you handled in your wholesale business last year.

6. What percent of last year's wholesale revenue from salted, dried and smoked fish came from fish that was:

bought locally _____ %

7. What percent of your purchases (dollars) of this locally bought salted, dried and smoked fish came from:

local fishermen _____ %

the auction _____ %

wholesalers/brokers _____ %

100 %

8. What percent of last year's wholesale revenue from salted, dried and smoked fish came from fish that was:

imported _____ %

(Q.6 and Q.8 should equal 100%)

9. What percent of your purchases (dollars) of this imported salted, dried and smoked fish came from:

Mainland _____ %

foreign _____ %

100 %

10. What percent of your total wholesale sales of salted, dried and smoked fish was to:

local retailers _____ %

local wholesalers _____ %

local processors _____ %

export _____ %

100 %

Now, I have a few questions about the FISHCAKE you handled in your wholesale business last year.

11. What percent of last year's wholesale revenue from fishcake came from fish that was:

bought locally _____ %

12. What percent of your purchases (dollars) of this locally bought fishcake came from:

local fishermen _____ %

the auction _____ %

wholesalers/brokers _____ %

100 %

13. What percent of last year's wholesale revenue from fishcake came from fish that was:

imported _____ %

(Q.11 and Q.13 should equal 100%)

14. What percent of your purchases (dollars) of this imported fishcake came from:

Mainland _____ %

foreign _____ %

100 %

15. What percent of your total wholesale sales of fishcake was to:

local retailers _____ %

local wholesalers _____ %

local processors _____ %

export _____ %

100 %

15. What percentage of your total sales in your wholesale business was in each of the following species of fish? (REFER TO SPECIES LIST, IF NEEDED.)

Tuna	_____ %	Billfish	_____ %	Mahimahi	_____ %
Akule	_____ %	Opelu	_____ %	Ono	_____ %
Reef fish	_____ %	Shark	_____ %	Bottom fish	_____ %
Crustaceans	_____ %	Mollusks	_____ %	Other	_____ %

TOTAL 100%

Finally, what was your:

17. Last year's total purchases (estimated) in your wholesale business of:

All fish and fish products _____ lbs.

\$ _____

Fresh fish _____ lbs.

\$ _____

Frozen fish _____ lbs.

\$ _____

18. Last year's total sales (estimated) in your wholesale business of:

All fish and fish products _____ lbs.

\$ _____

Fresh fish _____ lbs.

\$ _____

Frozen fish _____ lbs.

\$ _____

The National Marine Fisheries Service would like to thank you very much for helping with this research project.

NOAA ENUMERATION SURVEY ADDENDUM

Now, I have a few questions about the CANNED AND BOTTLED FISH you handled in your wholesale business last year.

1. What percent of last year's wholesale revenue from canned and bottled fish came from fish that was:

bought locally _____ %

2. What percent of your purchases (dollars) of this locally bought canned and bottled fish came from:

local fishermen _____ %

the auction _____ %

wholesalers/brokers _____ %

100 %

3. What percent of last year's wholesale revenue from canned and bottled fish came from fish that was:

imported _____ %

(Q.1 and Q.3 should equal 100%)

4. What percent of your purchases (dollars) of this imported canned and bottled fish came from:

Mainland _____ %

foreign _____ %

100 %

5. What percent of your total wholesale sales of canned and bottled fish was to:

local retailers _____ %

local wholesalers _____ %

local processors _____ %

export _____ %

100 %

Now, we would like to get an estimated breakdown of your wholesale business.

First of all, let's talk about the FRESH FISH you handled in your wholesale business last year.

6. What percent of last year's wholesale revenue from fresh fish came from fish that was:

bought locally _____ %

7. What percent of your purchases (dollars) of this locally bought fresh fish came from:

local fishermen _____ %

the auction _____ %

wholesalers/brokers _____ %

100 %

8. What percent of last year's wholesale revenue from fresh fish came from fish that was:

imported _____ %

(0.6 and 0.8 should equal 100%)

9. What percent of your purchases (dollars) of this imported fresh fish came from:

Mainland _____ %

foreign _____ %

100 %

10. What percent of your total wholesale sales of fresh fish was to:

local retailers _____ %

local wholesalers _____ %

local processors _____ %

export _____ %

100 %

Now, I have a few questions about the FROZEN FISH you handled in your wholesale business last year.

11. What percent of last year's wholesale revenue from frozen fish came from fish that was:

bought locally _____ %

12. What percent of your purchases (dollars) of this locally bought frozen fish came from:

local fishermen _____ %

the auction _____ %

wholesalers/brokers _____ %

100 %

13. What percent of last year's wholesale revenue from frozen fish came from fish that was:

imported _____ %

(Q.11 and Q.13 should equal 100%)

14. What percent of your purchases (dollars) of this imported frozen fish came from:

Mainland _____ %

foreign _____ %

100 %

15. What percent of your total wholesale sales of frozen fish was to:

local retailers _____ %

local wholesalers _____ %

local processors _____ %

export _____ %

100 %

IF "CANNED AND BOTTLED FISH," "SALTED, DRIED, AND SMOKED FISH," OR "FISHCAKE" IS MORE THAN 5% IN Q.5, ASK ADDENDUM QUESTIONS.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1					-21		21												85	78					85						
2				60	-34	36	-20	-23											25												
3								-19																							
4							-21				-29									-20	-20					-21	-21				
5		60			-43	31	-22	-21	-26	27					19	20		-20	21						20		26				22
6	-21	-34			-43		-68	36	24	30					-28	-40	32	-42				28	23	-22	-23			30	25	-21	-25
7		36			31	-68		-40		-19	28					54	-21		22					35	35					35	37
8	21	-20		-21	-22	36	-40				-33				-21	-27	21	-21	-32	22	23	31	26			22		33	26		
9		-23	-19		-21	24																									
10				-26	30	-19																									
11				27		28	-33											-21													
12			-29																												
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15				19	-28		-21							27																	
16				20	-40	54	-27																							28	
17					32	-21	21																								
18				-20			-21			-21																					
19		25			21	-42	22	-32																							
20	85			-20				22												92						100	85				
21	78		-20					23												92		32	37	28	33	92	98	30	36	28	33
22					28		31														32		87	21			61	96	87	21	
23					23		26														37	87					69	84	99		
24					-22	35															28	21			85		64	21		100	85
25					20	-23	35														33			85			71			85	99
26	85			-21				22												100	92						84				
27				26																85	98	61	69	64	71	84		59	70	64	73
28			-21		30		33														30	96	84	21			59		86	21	
29					25		26														36	87	99				70	86			
30					-21	35															28	21		100	85		64	21			86
31					22	-25	37									28					33			85	99		73				86

1 Number of full-time employees.

2 Engage in retail sales?

3 Engage in storage?

4 Engage in processing?

5 Percent business wholesale.

6 Percent wholesale revenue from fresh fish sales.

7 Percent revenue from frozen fish sales.

8 Percent wholesale revenue from tuna sales.

9 Percent wholesale revenue from akule sales.

10 Percent wholesale revenue from reef fish sales.

11 Percent wholesale revenue from crustacean sales.

12 Percent wholesale revenue from billfish sales.

13 Percent wholesale revenue from opelu sales.

14 Percent wholesale revenue from shark sales.

15 Percent wholesale revenue from mollusks sales.

16 Percent wholesale revenue from mahimahi sales.

17 Percent wholesale revenue from ono sales.

18 Percent wholesale revenue from bottom fish sales.

19 Percent wholesale revenue from other fish sales.

20 Total purchases--pounds.

21 Total purchases--dollars.

22 Fresh purchases--pounds.

23 Fresh purchases--dollars.

24 Frozen purchases--pounds.

25 Frozen purchases--dollars.

26 Total sales--pounds.

27 Total sales--dollars.

28 Fresh sales--pounds.

29 Fresh sales--dollars.

30 Frozen sales--pounds.

31 Frozen sales--dollars.

TOTAL SEAFOOD VOLUME IN HAWAII'S WHOLESALE FISH MARKETS

BY

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**ADMINISTRATIVE REPORT H-82-15
SEPTEMBER 1982**

INTRODUCTION

The Southwest Fisheries Center began analyzing Hawaii's seafood markets in 1978. An analysis of market structure was performed in 1981,¹ and seafood consumption was estimated by calculating net imports for the period 1970-77 (Hudgins 1980). Two surveys, including a preliminary enumeration of total seafood volume in 1980 and a monthly sampling of wholesale prices and quantities in late 1981 and early 1982, have also been conducted. This report presents tables based on the enumeration survey and provides quantitative information on the flow of seafood through Hawaii's wholesale market. Cross-sectional results from the enumeration survey were reported by the Laboratory in an earlier administrative report.² Later reports will cover the 1981-82 monthly surveys and a subsequent survey of retail markets.

Several qualifications pertain to the use of the data in this report. First, the 1980 enumeration survey consisted of 106 firms of a total of 119 identified as wholesale fish dealers. While most of the 13 firms that could not be surveyed were apparently small dealers, at least one is known to be a relatively large importer of frozen seafood. This report deletes from the 1980 sample one firm which acts primarily as a seafood importer, rather than as a wholesale dealer. Thus, the overall sample size for this report is 105 firms. Data are reported for the 1979 calendar year.

Second, not all seafood funnels through the wholesale market. Some goes directly from local harvesters to the retail sector while some imported seafood is purchased by major supermarkets and other large retail outlets directly from mainland or foreign wholesale firms or brokers. A survey of the latter segment of the market is being undertaken in the second half of 1982. Thus, although the 1980 survey covered a large percentage of the wholesale market, the results represent only a portion of the entire seafood market in Hawaii.

Third, the raw data have not yet been inspected and analyzed for anomalies that may have arisen in the interviewing process or in data coding. As such, the results should still be viewed as preliminary. However, initial use of the data indicates that the magnitude of any such error on a statewide basis is probably small. Only a few questions in the 1980 enumeration survey were related to actual dollar amount transactions. Instead, the survey concentrated on obtaining information on the percentage of wholesale business in various purchases, sales, and species categories. Therefore, most of the data in this report are calculated from these

¹Adams, M. F. 1981. Competition and market structure in the Hawaii fish industry. Southwest Fish. Cent. Admin. Rep. H-81-5. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 20 p.

²U.S. National Marine Fisheries Service. 1982. Preliminary results of a survey of wholesale fish dealers in Hawaii. Southwest Fish. Cent. Admin. Rep. H-82-14. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 17 p. + Appendix.

percentages "weighted" by each firm's total wholesale purchases or revenues. Tables have been constructed from the available data and in some cases firms did not answer all questions. Hence, totals may vary slightly between tables depending on the number of firms which responded.

Fourth, in order to protect the confidentiality of individual business enterprises, fish purchased from local auctions have been included in purchases from local fishing vessels.

If there are questions concerning the meaning of individual variables in these tables, the reader can refer to the previous administrative report which contains the survey questionnaire or contact the Laboratory.

RESULTS

Tables 1-12 present quantitative information on the flow of seafood through Hawaii's wholesale fish market.

Table 1.--Characteristics of Hawaii's wholesale seafood market in 1979.

<u>Category</u>	<u>Number</u>	
Total number of firms	118 firms	
Number of firms surveyed	105	
Type of business		
Wholesale	105 firms	
Retail	63	
Processing	27	
Storage	15	
Percent business which is wholesale (average)	72.9%	
Type of product		
Fresh	63 firms	
Frozen	63	
Canned and bottled	17	
Salted, dried, and smoked	26	
Fish cake	13	
Average starting year	1960	
Number of employees		
Full-time paid	1,490 employees	
Part-time paid	618	
Full-time unpaid	33	
Part-time unpaid	3	
<u>Market volume</u> ¹	<u>Value</u>	<u>Pounds</u>
Total purchases	\$55.0 million	30.4 million
Fresh	25.7	12.7
Frozen	22.9	17.5
Other	6.4	0.2
Total sales	\$77.1 million	30.6 million
Fresh	32.7	13.8
Frozen	33.1	12.8
Other	11.3	4.8

¹These summary figures have been adjusted to replace missing observations. This may account for more pounds sold than purchased and indicates the reason for deviations with other tables.

Table 2.--Type of product as percentage of wholesale sales revenue in 1979.

Type of product	Percent
Fresh	42.7
Frozen	43.8
Canned and bottled	6.5
Salted, dried, and smoked	3.5
Fish cake	3.4
Total	99.9
N = 102 firms	

Table 3.--Sales of major species groups as percentage of total wholesale revenue in 1979.

Species group	Percent
Tunas	27.0
Bottom fishes	18.6
Mahimahi (dolphinfish)	14.2
Crustaceans	11.4
Mollusks	7.7
Billfishes	3.2
Reef fishes	1.9
Ono (wahoo)	1.8
Akule (bigeye scad)	1.3
Opelu (mackerel scad)	1.2
Sharks	0.0
Others	11.6
Total	99.9
N = 102 firms	

Table 4.--Source of wholesale purchases as percentage of total wholesale purchases in 1979.

Source	Percent	Percent
Local fishers	35.0	
Local wholesalers/brokers	9.7	
Total local		44.7
Mainland imports	30.0	
Foreign imports	23.3	
Unspecified imports	1.3	
Total imports		54.6
Unspecified sources		0.7
Total		100.0
N = 99 firms		

Table 5.--Destination of wholesale products as percentage of total wholesale revenue in 1979.

Destination	Percent
Local retail	73.0
Local processors	1.1
Local wholesale	18.1
Export (mainland and foreign)	7.9
Total	100.1
N = 102 firms	

Table 6.--Purchases by product type and by source in 1979.

Fresh

Local		
Fishers ¹	\$18,022,008	
Wholesalers	4,325,010	
Not specified	1,931	
Total		\$22,348,949
Imports		
Mainland	\$1,546,021	
Foreign	196,911	
Not specified	660,000	
Total		\$2,402,932
Total fresh		\$24,751,881

Frozen

Local		
Fishers ¹	\$ 23,080	
Wholesalers	465,284	
Total		\$488,364
Imports		
Mainland	\$13,133,950	
Foreign	8,019,095	
Total		\$21,153,045
Total frozen		\$21,641,409

Canned and bottled \$2,992,142

Salted, dried, and smoked \$2,078,465

Fish cake \$1,152,005

Total purchases² \$52,615,902
=====

¹Includes auction fish.

²Totals are based on 99 firms for this and remaining "purchases" tables, unless otherwise noted.

Table 7.--Source of purchases by product type in 1979.

Local sourcesLocal fishers¹

Fresh	\$18,022,008	
Frozen	23,080	
Canned and bottled	0	
Salted, dried, and smoked	212,232	
Fish cake	158,000	
Total		\$18,415,320

Local wholesalers/brokers

Fresh	\$4,325,010	
Frozen	465,284	
Canned and bottled	62,405	
Salted, dried, and smoked	251,876	
Fish cake	3,000	
Total		\$5,107,575

Local not specified (fresh) \$1,931

Total local purchases \$23,524,826

Imports

Mainland

Fresh	\$ 1,546,021	
Frozen	13,133,950	
Canned and bottled	505,240	
Salted, dried, and smoked	442,979	
Fish cake	133,575	
Total		\$15,761,765

Foreign

Fresh	\$ 196,911	
Frozen	8,019,095	
Canned and bottled	2,413,048	
Salted, dried, and smoked	962,228	
Fish cake	687,000	
Total		\$12,278,282

Imports not specified (fresh) \$660,000

Total imported purchases \$28,700,047

Others not specified

\$391,029

Total \$52,615,902

=====

=====

¹Includes auction fish.

Table 8.--Destination of products in 1979.

<u>Local retail</u>		
Fresh	\$15,888,322	
Frozen	29,399,144	
Canned and bottled	4,504,577	
Salted, dried, and smoked	2,082,717	
Fish cake	2,239,619	
Total		\$54,114,379
<u>Local processor</u>		
Fresh	\$725,174	
Frozen	72,291	
Canned and bottled	0	
Salted, dried, and smoked	0	
Fish cake	0	
Total		\$797,465
<u>Local wholesale</u>		
Fresh	\$9,786,999	
Frozen	2,966,597	
Canned and bottled	73,722	
Salted, dried, and smoked	527,376	
Fish cake	76,400	
Total		\$13,431,094
<u>Export</u>		
Fresh	\$5,288,697	
Frozen	61,861	
Canned and bottled	239,400	
Salted, dried, and smoked	0	
Fish cake	234,375	
Total		\$5,824,333
Total sales ¹		\$74,167,271
=====		=====

¹Totals are based on 102 firms for this and remaining sales tables, unless otherwise noted.

Table 9.--Purchases of major species groups in 1979.

Species group	Number of firms	Mean	Total
Tunas	44	\$372,022	\$16,368,950
Bottom fishes	39	168,703	6,579,414
Mahimahi (dolphinfish)	40	151,479	6,059,168
Crustaceans	30	238,417	7,152,500
Mollusks	23	157,966	3,633,210
Billfishes	16	119,868	1,917,884
Reef fishes	22	42,633	937,922
Ono (wahoo)	23	44,030	1,012,699
Akule (bigeye scad)	17	33,186	564,154
Opelu (mackerel scad)	12	37,843	454,115
Sharks	4	14,775	59,100
Others	36	187,748	6,758,925
Total	105	\$490,458	\$51,498,040

Table 10.--Revenue from major species groups in 1979.

Species group	Number of firms	Mean	Total
Tunas	44	\$457,253	\$20,119,139
Bottom fishes	40	345,417	13,816,673
Mahimahi (dolphinfish)	42	252,364	10,599,282
Crustaceans	32	265,332	8,490,626
Mollusks	25	229,097	5,727,416
Billfishes	16	150,754	2,412,063
Reef fishes	23	60,784	1,398,026
Ono (wahoo)	23	58,039	1,334,892
Akule (bigeye scad)	18	52,817	950,704
Opelu (mackerel scad)	12	75,195	902,337
Sharks	4	15,075	60,300
Others	39	220,401	8,595,644
Total	105	\$708,639	\$74,407,102

Table 11.--County wholesale seafood markets in 1979.

Category	Hawaii	Kauai	Maui	Subtotal	Oahu	State ¹
Number of firms	15	6	9	30	75	105
Percent				29%	79%	
Total sales ²						
Million dollars	11.76	0.54	10.25	22.55	52.34	74.89
Percent				30%	70%	
Million pounds	5.50	0.30	2.80	8.60	20.56	29.16
Percent				29%	71%	
Sales of fresh seafood						
Million dollars	10.61	0.45	4.09	15.15	16.90	32.05
Percent				47%	53%	
Million pounds	4.87	0.22	1.52	6.61	7.15	13.76
Percent				48%	52%	
Sales of frozen seafood						
Million dollars	--	--	--	6.74	26.07	32.81
Percent				21%	79%	
Million pounds	--	--	--	1.76	9.98	11.74
Percent				15%	85%	
Defacto population ³	91,000	43,600	80,900	215,800	797,100	1,012,900
Percent				21%	79%	

¹Data include sales between wholesale dealers.

²Total sales include not only fresh and frozen seafood products but also processed forms of seafood.

³Defacto population includes residents on-island (not traveling) and visitors (tourists).

CONCLUSION

This composite profile of total seafood purchases at the wholesale level is generally consistent with other indications of total seafood volume in Hawaii. Hudgins (1980) estimated local consumption to be 19.0 million pounds for 1977, worth approximately \$34.8 million in 1979 prices. By comparison, the 1980 enumeration survey found wholesale purchases for local consumption were 21.1 million pounds in 1979, worth \$38.3 million. The enumeration survey total of \$38.3 million does not include seafood which bypasses the wholesale sector. Therefore, taking into consideration the differences in coverage and methodology, the results from the 1980 enumeration survey suggest that Hawaii's seafood demand is even greater than that estimated by Hudgins who pointed out that on a per capita basis Hawaii consumers led the nation by a factor of two.

Table 12.--Hawaii seafood consumption obtained through local wholesale dealers in 1979.¹

Foreign imports	\$12.3 million
Mainland imports	15.8
Local purchases	23.5
Less intrawholesale and export ²	-13.3
Local consumption	38.3
Local consumption ³	21.1 million pounds

¹As reported by wholesale dealers on the 1980 enumeration survey.

²Although wholesale dealers reported \$5.1 million purchases from other wholesale dealers, \$13.4 million were reported as sales to other wholesale dealers. Because some sales may have been outside the survey, we have chosen the mean value of the two measures to correct for double counting. Export share of purchases was estimated at \$4.15 million.

³Calculated by subtracting from reported purchases an amount equivalent to the proportion of wholesale revenue exported or sold to other wholesale dealers.

The 1980 enumeration survey provides an updated picture of Hawaii's demand for seafood. While most locally harvested fish goes into the fresh fish market, an equivalent share of the overall seafood market comes from imported frozen seafood. The latter includes not only crustaceans and mollusks, which are generally not available in large supply from the local commercial fishery, but also a wide range of frozen fillets and specialty seafoods. Thus, seafood marketing in Hawaii involves dealing with a heterogeneous variety of products. Although there is a strong demand for locally produced fresh fish, local fishers face substantial competition from frozen imports throughout the seafood market. One way in which the local wholesale dealers are dealing with this competition is through exports of fresh and fresh-frozen fish which now amount to almost 10% of total wholesale trade.

Once the 1982 survey of retail fish sales is completed, we will be able to provide detailed estimates of seafood consumption in Hawaii and provide the first overall quantification of total volume through all levels of Hawaii's marketing network. Such estimates should be helpful to those involved in marketing seafood in Hawaii as well as those involved in fisheries development and fisheries management.

LITERATURE CITED

Hudgins, L. L.

1980. Per capita annual utilization and consumption of fish and shellfish in Hawaii, 1970-77. Mar. Fish. Rev. 42(2):16-20.



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
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SEAMOUNT FISHERY, FOREIGN VESSEL OBSERVER REPORT

ASO MARU (July 17-August 10, 1982)

By

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Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii 96812

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September 1982
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

NOT FOR PUBLICATION

Figure 1.--NET DIMENSIONS AND CHARACTERISTICS

Type of Vessel Stern trawler

Observation Period July 17-August 10, 1982

Trawl Doors: Shape rectangular

Type steel

Dimensions 2.2 m. x 4.4 m.

Weight 3,262 kg.

Floater: Number 42

Size 24 ea. 360 mm; 10 ea. 300 mm; 8 ea. 460 mm

Material CYCOLAC Floats (elastic)

Shape Round (spherical)

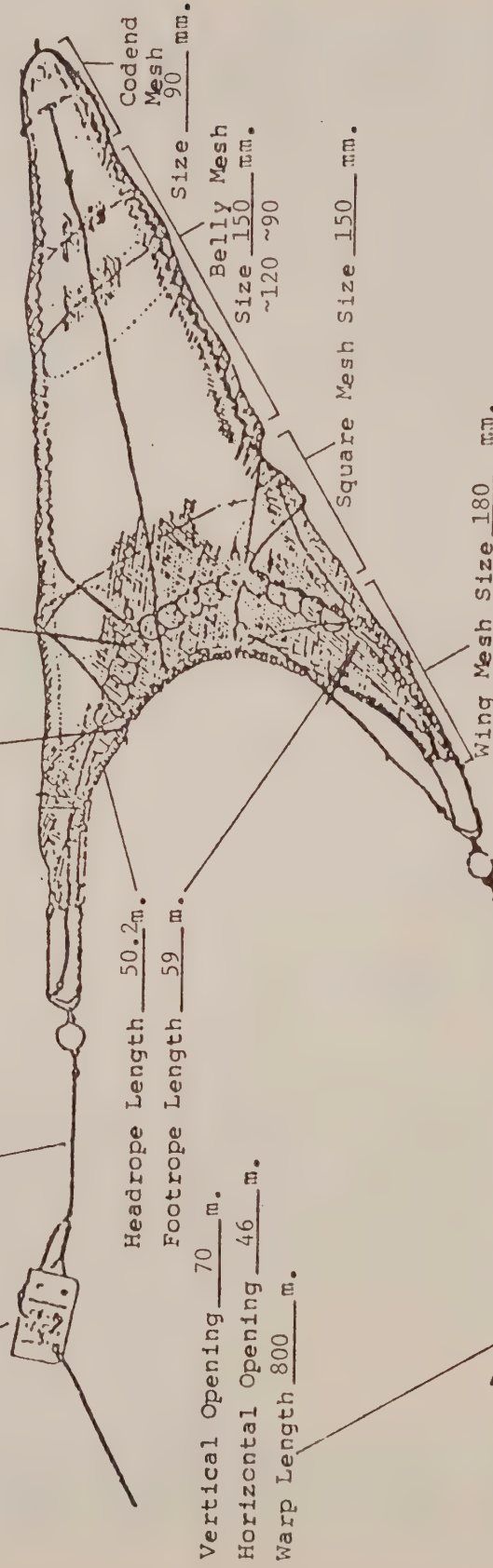
Dandyline Length 60 m.

Bobbins: Number 21

Size 16 ea. 530 mm; 3 ea. 800 mm; 2 ea. 500 mm

Material steel ball, rubber ball

Shape round roller



Net Recorder:

Name Furuno

Model Number 155-0334 (FNR-50)

Frequency 50 kHz

Fish Finder:

Name Kaijo Denki

Model Number W-655-CHR-562-JM

Frequency 200 kHz 50 kHz 24 kHz

Paper Type Wet 0 Dry X

Speed of Advance

FISHING ACTIVITIES

Trawl Operations

The Aso Maru made 35 hauls at Northwest Hancock (lat. 30°16'N, long. 178°42'E). The average trawling time per haul was 66 min. The ship made 59 hauls at Southeast Hancock (lat. 29°48'N, long. 179°04'E). The average trawling time per haul at this location was also 66 min. Thirty-two hauls were made at K Bank (lat. 29°40'N, long. 179°20'E), where the average trawling time per haul was 33 min. The trawl gear dimensions are given in Figure 1. Data on catch per unit of effort by area and species are given in Table 2.

Table 2.--Catch per unit of effort by area and species.

	Northwest Hancock Seamount	Southeast Hancock Seamount	K Bank
No. hauls	35	59	32
Total minutes ¹ (trawl in water)	2,295	3,910	1,040
Armorhead			
Total catch (kg)	13,188	11,517	813
Kilogram/minute	5.75	2.95	0.78
Alfonsin			
Total catch (kg)	7,896	4,477	49,312
Kilogram/minute	3.44	1.15	47.42
Other species			
Total catch (kg)	6,777	10,285	105
Kilogram/minute	2.95	2.63	0.10
All species			
Total catch (kg)	27,860	26,279	50,230
Kilogram/minute	12.14	6.72	48.30

¹The recorded trawl times include periods when the ship was turning and not over the seamount.

Overall Catch

Out of a total of 104.4 metric tons (MT) caught at the Hancock Seamounts during July 18-August 9, 25.5 MT (24.4%) were armorhead, 61.7 MT (59.1%) were alfonsin, and 17.2 MT (16.5%) were other species (Table 3).

Table 3.--Trawl catch by species and area (in metric tons).

Species	Northwest Hancock Seamount	Southeast Hancock Seamount	K Bank	Total
Armorhead	13.2	11.5	0.8	25.5
Alfonsin	7.9	4.5	49.3	61.7
Others	<u>6.8</u>	<u>10.3</u>	<u>0.1</u>	<u>17.2</u>
Total	27.9	26.3	50.2	104.4

Precious Coral

Based on my sampling I estimated that approximately 17 kg of coral were incidentally caught during my stay on the vessel. However, this is very probably a gross exaggeration of the actual catch. Although the net often brought up bottom material, coral was rare.

Shipboard Processing of Catch

The catch was processed into headed and gutted frozen fish, frozen whole fish, frozen fillets, and frozen ovaries (Table 4). In addition to armorhead and alfonsin, the following were processed (frozen): butterflyfish, Hyperoglyphe japonica; rudderfish, Ariomma lurida; boga fish, Emmelichthys struhsakeri; and red-tailed opelu, Decapterus tabl.

Table 4.--Shipboard products (vessel estimates in metric tons).

Species	Frozen fish (headed and gutted)	Frozen whole fish	Frozen fillets	Frozen ovaries
Armorhead	13.9	0.0	0.0	0.0
Alfonsin	31.8	0.5	0.0	0.3
Others	3.8	7.9	0.5	0.0

I also observed that john dory fish, Zenopsis nebulosa, were being processed, but these apparently were not frozen. They were probably used for crew consumption.

All fish or parts of fish that were unsuitable for freezing (inedible species, heads, viscera, small or badly damaged fish) were converted to fish meal and fish oil. No records were kept on the weights of particular species groups that were so utilized. Overall, 6.8 MT of fish meal and 2.4 MT of fish oil were produced.

BIOLOGICAL OBSERVATIONS

Target Species

1. Armorhead, Pentaceros richardsoni (Species code: 080)
(Japanese name: Kusakari tsubodai) (Table 5)

Most of these fish were caught at Northwest and Southeast Hancock Seamounts. In collecting length-sex data I separated the armorhead into three body types: fat, lean, and medium. This division is based on the amount of fat on the dorsal side and the general body shape. The causes of the variation in body type are unknown.

2. Alfonsin, Beryx splendens (Species code: 081)
(Japanese name: Kinmedai) (Table 6)

Most of the alfonsin were caught at K Bank during the last 5 days of the cruise. Many were quite large. This species made up the bulk of the catch, an unusual occurrence in this fishery. Some of the small fish could not be sexed.

ITINERARY

July 17	- Departed Honolulu. Arrived Midway. Embarked <u>Aso Maru</u> .
18	- Arrived Hancock. Began sampling.
27	- Departed FCZ. Sampling ended.
August 5	- Reentered FCZ. Sampling resumed.
9	- Departed FCZ. Sampling ended.
10	- Transferred to cargo ship.
16	- Disembarked at Dutch Harbor, Alaska. Departed Dutch Harbor. Arrived Anchorage. Departed Anchorage. Arrived Seattle.
20	- Departed Seattle. Arrived Honolulu.

Table 5.--Observations on armorhead, Pentaceros richardsoni.

Body type	Fat	Lean	Medium	Total
Northwest Hancock Seamount				
Percent of sample	53	15	32	100
Number measured	145	42	86	1381
Length range (mm)	280-335	258-314	272-333	258-339
Average length (mm)	307	288	300	303
Number weighed and sexed	40	9	21	2100
Average weight (kg)	0.49	0.32	0.41	0.45
Number (%) males	14 (35.0%)	7 (77.8%)	14 (66.7%)	250 (50.0%)
Number (%) females	26 (65.0%)	2 (22.2%)	7 (33.3%)	250 (50.0%)
Southeast Hancock Seamount				
Percent of sample	59	13	28	100
Number measured	71	16	33	3186
Length range (mm)	286-327	275-318	281-316	264-327
Average length (mm)	307	292	299	301
Number weighed and sexed	24	10	7	41
Average weight (kg)	0.47	0.35	0.40	0.43
Number (%) males	7 (29.2%)	9 (90.0%)	3 (42.9%)	19 (46.3%)
Number (%) females	17 (70.8%)	1 (10.0%)	4 (57.1%)	22 (53.7%)
K Bank				
Percent of sample	76	5	19	100
Number measured	43	3	11	57
Length range (mm)	281-332	275-301	290-315	275-332
Average length (mm)	304	285	301	302
Number weighed and sexed	17	2	5	24
Average weight (kg)	0.44	0.32	0.42	0.42
Number (%) males	10 (58.8%)	2 (100.0%)	4 (80.0%)	16 (66.7%)
Number (%) females	7 (41.2%)	0 (0.0%)	1 (20.0%)	8 (33.3%)

¹Includes 108 fish that were measured but not classified by body type.

²Includes 30 fish that were weighed and sexed but not classified by body type.

³Includes 66 fish that were measured but not classified by body type.

Table 6.--Observations on alfonsin, Beryx splendens.

Seamount	Northwest Hancock	Southeast Hancock	K Bank
Number measured	269	121	485
Length range (mm)	141-418	148-328	212-481
Average length (mm)	210	187	370
Number weighed and sexed	141	0	133
Average weight (kg)	0.15	--	1.13
Number (%) males	24 (58.5%)	--	87 (65.4%)
Number (%) females	17 (41.5%)	--	46 (34.6%)

¹An additional 61 fish were weighed but could not be sexed.

RECORDS

The following records were kept:

Scientists log
Daily trawl haul form
Species composition from basket samples
Size-frequency log

OBSERVER

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Hawaii 96812

82-17C

Southwest Fisheries Center Administrative Report H-82-17C

USING ARTIFICIALLY INDUCED LOCOMOTION IN THE
MEASUREMENT OF ACTIVE RESPIROMETRY RATES
FROM SKIPJACK TUNA, KATSUWONUS PELAMIS

Walter N. Ikehara
Consultant

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National Marine Fisheries Service
2570 Dale Street
Honolulu, Hawaii

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Final Report for a National Marine Fisheries Service
Contract (Purchase Order No. 81-ABA-2116)
Honolulu, Hawaii

NOT FOR PUBLICATION

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PREFACE

This report was prepared under contract (Purchase Order No. 81-ABA-2116, August 6, 1981) by Walter N. Ikehara, graduate student, University of Hawaii. The contract objective was to build a system for inducing locomotion in restrained tuna through brain stimulation and to test the feasibility of using this system for measuring metabolic rates at high sustained swimming speeds. The description of the methodologies employed provides a guide for future research activities in this area. Since the report has been prepared under contract, the statements, findings, conclusions, and recommendations herein are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

Richard W. Brill
Fishery Biologist

September 30, 1982

INTRODUCTION

The purpose of this contract was to design and construct an apparatus for utilizing artificially induced locomotion (AIL) (Kashin et al. 1981) in the measurement of oxygen uptake at various activity levels from restrained, live skipjack tuna, Katsuwonus pelamis. The AIL technique involves electrically stimulating the midbrain of the skipjack tuna causing rhythmic, coordinated swimming motions to be generated. In other fish, this technique has been shown to produce coordinated swimming behavior in a free-swimming fish when stimulating electrodes are implanted (Kashin et al. 1974).

In the past, attempts have been made to measure oxygen uptake rates at high swim speeds from free-swimming skipjack tuna with little success. The methods included, chasing skipjack tuna in annular tanks at high swimming speeds, forcing skipjack tuna to swim in water tunnels while increasing the speed of water flow, and cannulating the gills of actively swimming tuna in small tanks. None of these methods were particularly successful, mainly because the skipjack tuna either failed to swim properly in a forced situation or the measurement of dissolved oxygen in rapidly flowing water proved to be infeasible.

Although some respirometry data have been obtained at near minimum swimming speeds (Gooding et al. 1981), no measurements have been made at higher swimming speeds. When Kashin et al. (1981) showed that simulated locomotory activity could be induced in restrained skipjack tuna, the possibility arose that this method could be used to obtain respirometry data from actively "swimming" skipjack tuna in a restraint system where oxygen uptake measurements and other physiological measurements are facilitated. This contract was funded to incorporate AIL into a restraint system with the capability of measuring oxygen uptake rates, tail-beat frequencies, and other physiological parameters.

OBJECTIVES

1. The first task was to produce AIL in restrained skipjack tuna and to investigate the stimulus parameters needed to modulate the frequency of tail beats so that varying "swim speeds" could be produced.

2. A restraint system was also required to hold the anterior half of the fish stable and motionless so that the stimulating electrodes could be placed accurately in the midbrain of the fish and be free from motion artifacts. Simultaneously, the posterior half of the fish was to be unrestrained to permit locomotory activity to occur. Other apparatus would be constructed to record the frequency of tail beats for calculation of equivalent swim speeds (Yuen 1966).

3. Next, an apparatus had to be designed and built for the measurement of dissolved oxygen in water before and after passage over the gills. No cross-contamination of the pre-gill and post-gill water could be allowed. The rate of waterflow through the gills was to be monitored so that the oxygen uptake could be calculated.

METHODS AND MATERIALS

1. Artificially Induced Locomotion

Several live skipjack tuna were anesthetized with sodium thiopental injected intramuscularly at a dose of about 20 mg/kg wet weight. The anesthetized fish were transported onto a temporary restraint cradle and strapped securely. A stainless steel tube was inserted into the mouth of the fish and oxygenated seawater was supplied for respiration. After a short period for recovery, the surgery to expose the brain was begun. Small injections of Lidocaine, a local anesthetic, were made into the muscle overlying the skull of the skipjack tuna. The skin over the skull was incised and folded back and the underlying muscle bundles were retracted. Using a bone rongeurs, the skull bone directly over the cerebellum was cut away, and the fatty tissue and dural membranes were removed exposing the entire cerebellum to view.

Screw clamps were placed on the snout of the fish, clamping it tightly to the stainless steel perfusion tube. The micromanipulator was positioned over the skull opening, and the stimulating electrodes were attached to the manipulator. In bipolar stimulation, two sharpened tungsten electrodes with uninsulated tips were used as stimulating electrodes. In monopolar stimulation, only one tungsten stimulating electrode was used and a stainless steel syringe needle inserted into the anterior dorsal muscle was used as the indifferent electrode. The monopolar electrode seemed to be slightly more effective than the bipolar electrodes and caused less trauma. The electrodes were connected to the output of a Grass S9D Stimulator, and the entire unit was grounded by a stainless steel plate immersed in the seawater.

The most effective area of stimulation seemed to be centered on the midline of the brain, slightly less than half the length of the cerebellum posterior to the anterior edge. The monopolar electrode tip was placed between 6 and 7 mm deep. The lateral position of the stimulating electrode was rather critical, as deviations from the midline as small as 0.5 mm caused uneven tail flexures (Figure 1).

The effective stimulus parameters varied with individual fish but can be summarized as follows. The effective stimuli were repetitive, biphasic, of positive polarity, from 2 to 4.5 volts, of 2 to 5 ms duration, at 60 to 150 pulses per second. The frequency of tail beats could be modulated by increasing the frequency and slightly decreasing the duration. The threshold of stimulation varied with individual fish. The period of stimulation varied from several seconds to several minutes. The tail-beat responses at higher tail-beat rates generally began decreasing in amplitude after a few minutes. Long periods of stimulation are not recommended because lesions could be produced.

If the electrode is placed correctly, the fish will show no tail movement while not being stimulated, although opercular movements will occur. When the stimulator is turned on, the tail will begin moving in a coordinated fashion appearing like normal tail beats. When the stimulator is turned off, the tail beats will cease (Figure 2).



Figure 1.--The placement of the stimulating electrode. The photograph shows the stimulating electrode entering the cerebellum. A retractor is holding muscle bundles apart. The pineal window can be seen at the center right of the photograph. Anterior is to the right.

It is important that only fish in good condition be used for this experiment. The fish should be handled rapidly and with care, as the time that the fish is not respiring should be minimized. The gill perfusion water should be saturated with oxygen. Excess anesthetic should not be used, and the fish can be temporarily quieted by covering the eyes with an opaque material.

2. Live Restraint System

A restraint system was designed and built to hold the fish securely in position for the electrode placement yet permit movement of the tail for induced swimming motion. A rectangular plexiglass box formerly used for stasis respirometry measurements (Brill 1979) was modified by the addition of several new partitions (Figure 3). A plexiglass partition with sliding plexiglass clamps shaped to fit the lateral surface of the skipjack tuna's body was fitted into the box about one-third of the way back from the anterior wall of the box. The clamping surfaces were padded with foam rubber to protect the fish's body. The clamps held the fish's body just posterior to the pectoral fins and could be secured tightly enough to isolate the anterior half of the fish from the motion of the tail. Another partition

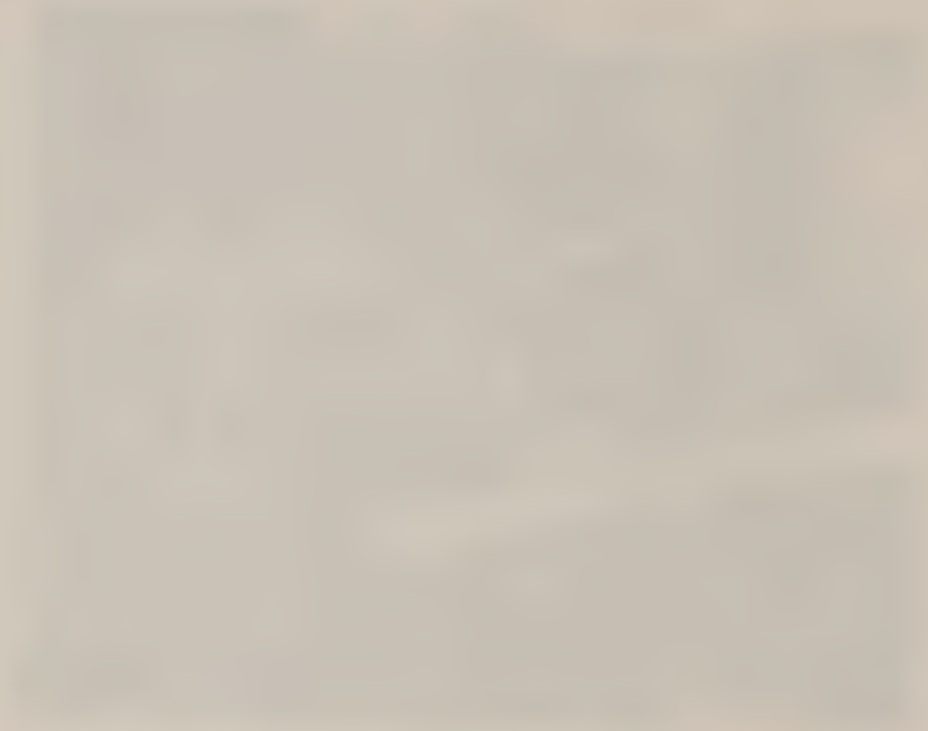




Figure 2.--A skipjack tuna being stimulated with the AIL technique. This photograph from the Kashin et al. (1981) experiments shows a skipjack tuna beating its tail in response to AIL stimulation. The electrode holder and the micromanipulator can be seen at left. Electromyographic recording electrodes can be seen at right.

placed just posterior to the anterior wall of the box had an opening shaped to fit around the snout of the fish, padded with firm foam rubber so that it clamped and sealed the snout. Additional screw clamps around the opening could be used to secure the fish's snout against the padded stainless steel perfusion tube protruding into the box from the anterior wall. The box and clamping partitions were designed for a skipjack tuna ranging in size from 1 to 2 kg in weight, the size of skipjack tuna usually maintained in captivity at the Kewalo Research Facility.

In this manner, the anterior portion of the fish could be held securely, sealed against contamination of exhaled water by inhaled water, yet permit collection of exhaled water with a cannulated manifold fitted into the opercular openings. The posterior portion of the box was left open to permit free tail movement and drainage of exhaled water. The box was bolted to a plexiglass water table on the electrophysiology table.

The tail-beat frequency can be monitored by the same method used in Kashin et al. (1981) utilizing a linkage to the caudal peduncle and a potentiometer used in a voltage divider circuit fed to a chart recorder.

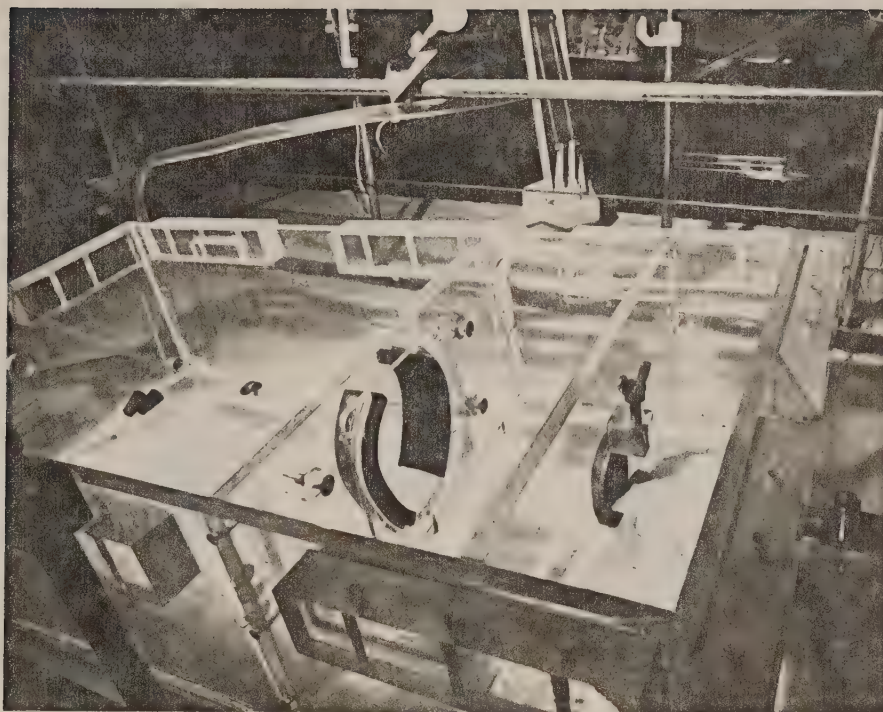


Figure 3.--The plexiglass box used in the restraint system. From right to left, the stainless steel perfusion tube with jaw seals, the first partition with the snout seal and snout clamps, and the second partition with the sliding body clamps can be seen. The compartments can be sealed at the snout and body partitions. Part of the electrophysiology table and support apparatus can also be seen.

3. Oxygen Measurement Apparatus

An apparatus was designed and constructed to permit the sampling of water before (inhalant) and after passage (exhalant over the fish's gills). A plexiglass chamber was constructed to hold a Yellow Springs Instruments (YSI) oxygen probe so that the inhalant flow passed over the membrane of the probe. An outlet was also provided for taking samples in a BOD bottle for Winkler titration (Figure 4).

The exhalant water, after passage over the gills, was sampled by a manifold with three cannulae in each opercular opening. Six cannulae, three from each side of the fish, led to a cylindrical plexiglass chamber designed so that the water forcefully passed over the oxygen probe membrane and also could be sampled into a BOD bottle for later Winkler titration. The exhalant probe chamber was placed lower than the opercular manifolds so that the water siphoned out of the opercular chambers. This caused a rapid flow through the cannulae, effectively collecting most of the exhalant flow (Figure 5).



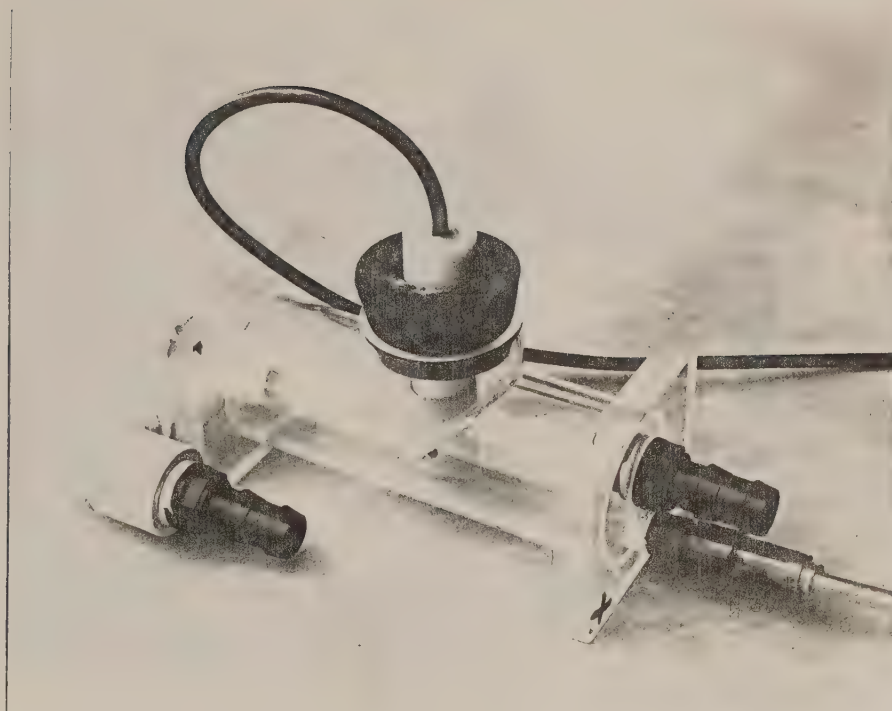


Figure 4.--The inhalant oxygen probe chamber. Oxygenated seawater enters the upper port on the right, passes through the oxygen probe, and exits from the left. The tube at the lower right is the Winkler sampling port. The stopper with the oxygen probe can be removed and replaced with a solid stopper.

The oxygen probe was connected to a YSI Model 57 Dissolved Oxygen Meter. This unit was calibrated with saturated air and was provided with salinity and temperature compensation. As a check on the meter, a Winkler titration apparatus was to be used to assay samples taken at the same time the oxygen meter was used.

The seawater for the perfusion system was oxygenated with an in-line airstone fed by a regulated oxygen tank. To prevent oxygen bubbles from contaminating the inhalant water, a large plastic barrel was used as an open reservoir. The water flowed by gravity from the reservoir through an in-line flowmeter to the inhalant probe chamber, then into the perfusion tube inserted into the fish's mouth. Leakage of inhalant water was prevented by a foam block shaped to seal the area between the fish's mouth and the perfusion tube. (See Figure 6 for a schematic diagram.)

Since all the inhalant water was monitored by the flowmeter and dissolved oxygen measurements could be made before and after passage over the gills, the total oxygen uptake of the fish could be calculated.

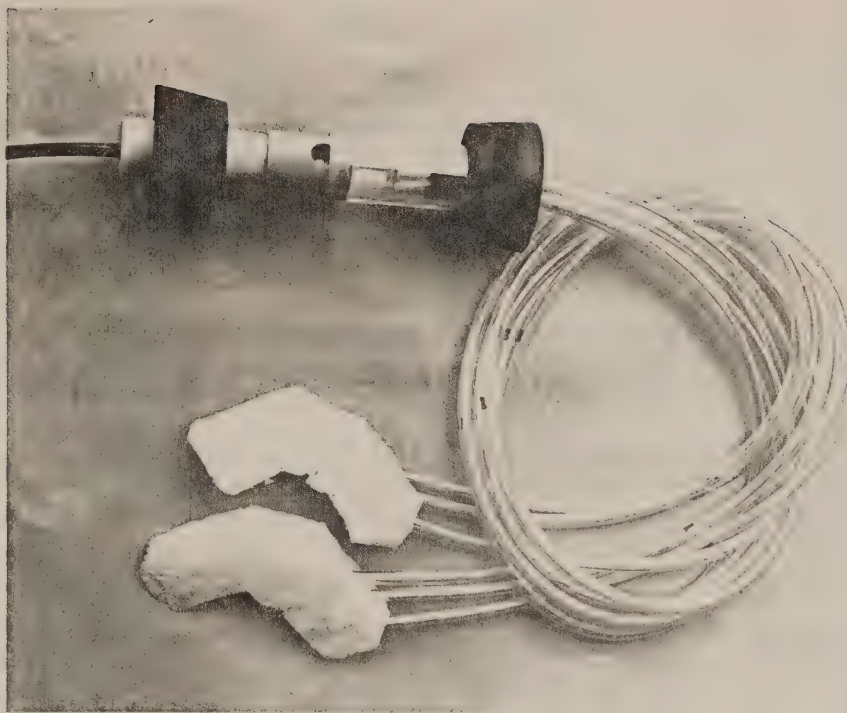


Figure 5.--The exhalant oxygen probe chamber with cannulae. Exhaled seawater is taken up by the cannulae held by the foam opercular manifolds at the lower left, passes over the oxygen probe, and is drained through an outer cylinder (not shown) equipped with a Winkler sampling port. The design of the probe chamber causes seawater to pass forcefully over the probe membrane, eliminating the need for stirring.

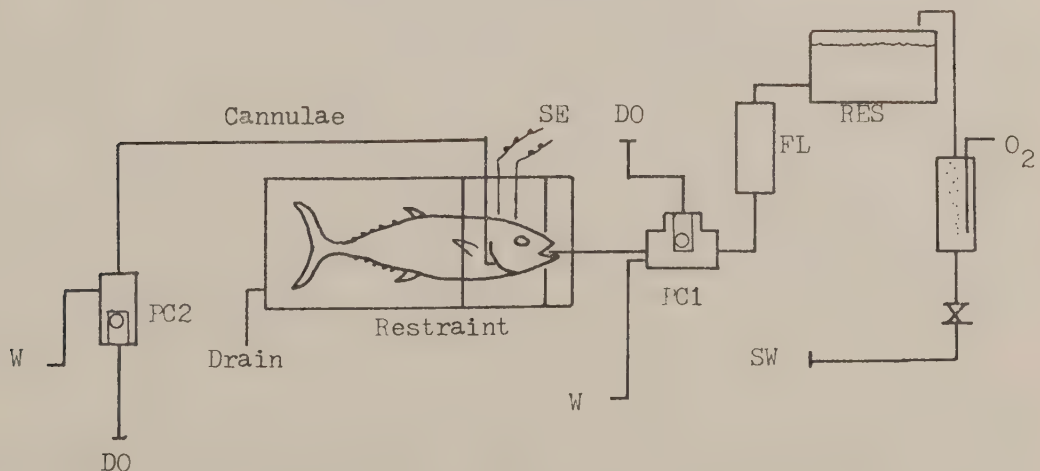


Figure 6.--The restraint system and the oxygen measurement system. In order of direction of flow: SW = seawater input, O₂ = oxygen, RES = open reservoir, FL = flowmeter, PC1 = inhalant oxygen probe chamber, DO = dissolved oxygen probe, W = Winkler port, SE = stimulating electrodes, PC2 = exhalant probe chamber.

SUMMARY OF RESULTS

1. The experiment of Kashin et al. (1981) was successfully reproduced on three skipjack tuna. The parameters for electrical stimulation were studied and effective ranges were found. The frequency of tail beats could be varied by changes in stimulus parameters. The optimal location for stimulating electrodes was mapped in relation to the brain. A monopolar stimulating electrode was found to be slightly more effective than bipolar electrodes.

2. A restraint system was designed and constructed to hold the fish's head immobile and yet permit free tail movement. Access to the fish's head and brain was unimpaired.

3. An oxygen measurement system was designed and constructed to utilize polarographic oxygen electrodes for dissolved oxygen measurements of inhalant and exhalant seawater. Water samples for Winkler titration analyses could also be collected. A cannula system was designed and tested for collecting exhalant water from the opercular openings.

4. No measurements were obtained of oxygen uptake rates at various activity levels from skipjack tuna. Although experiments were planned with restrained fish, various factors such as the lack of suitably sized fish and lack of time prevented the accomplishment of these experiments.

DISCUSSION

One obstacle to obtaining valid active respirometry measurements in the restrained AIL system is the time needed, after introduction of the fish to the box, for stress-related phenomena to subside. Barrett and Connor (1964) found that blood lactate levels in skipjack tuna were low immediately after capture, but increased to a high level in about 30 to 90 minutes after capture. Approximately 1 to 2 hours were required for lactate levels to fall to initial capture levels. It is possible that any active respirometry measurements made before such time would be biased by stress phenomena. Any respirometry rates obtained via the restrained AIL technique would have to be compared to resting respirometry rates measured after the fish was still and had stabilized, near the end of the experiment. If the fish survived for long periods in the restraint system, then resting respirometry rates could also be measured before active measurements were begun. However, the accumulation of lactate will inevitably occur as the fish is exercised in the restraint system.

The stamina of the fish under stimulation may also become a problem. The skipjack tuna I used were not able to maintain a high rate (i. e., higher than "cruise" rate) of tail beating for long periods of time. In most cases, they fatigued within a few minutes of the onset of stimulation. It is possible that the fish may not last long enough to obtain multiple measurements. This effect may also be due to the fact that weakened fish were used in the initial stimulation experiments, as healthy fish were reserved for behavior studies. If healthy fish are used for AIL experiments, then stamina may not become a problem.

It is important that the restraint system, and all support systems for the apparatus, be as rigid as possible. The skipjack tuna can generate considerable inertial forces when actively tail beating. If there is compliance in the system, the electrodes will move in relation to the brain, damaging the midbrain and brainstem. An implanted electrode system would be desirable, if the optimum location for the electrodes can be determined in advance, however, some adjustability in the location of electrodes would still be desirable.

The system developed for the AIL technique and oxygen measurement is also applicable for the measurement of other physiological parameters. For example, it should be possible to flood the posterior compartment of the restraint box and seal it so that power measurements can be made by measuring the rise in temperature of the water as the fish beats its tail. Heat flow sensors can be attached to the fish for heat flux measurements and electromyographic recordings can also be made from an active fish.

ACKNOWLEDGMENTS

A sincere thank you to Dr. Andrew E. Dizon, Randolph K. C. Chang, and the staff of the Kewalo Research Facility, Honolulu Laboratory, National Marine Fisheries Service for the use of their facilities and their cooperation.

REFERENCES

- Barrett, I., and A. R. Connor.
1964. Muscle glycogen and blood lactate in yellowfin tuna, Thunnus albacares, and skipjack tuna, Katsuwonus pelamis, following capture and tagging. [In Span. and Engl.] Bull. Inter-Am. Trop. Tuna Comm. 9:219-268.
- Brill, R. W.
1979. The effect of body size on the standard metabolic rate of skipjack tuna, Katsuwonus pelamis. Fish. Bull., U.S. 77:494-498.
- Gooding, R. M., W. H. Neill, and A. E. Dizon.
1981. Respiration rates and low-oxygen tolerance limits in skipjack tuna, Katsuwonus pelamis. Fish. Bull., U.S. 79:31-48.
- Kashin, S. M., A. G. Feldman, and G. N. Orlovsky.
1974. Locomotion of fish evoked by electrical stimulation of the brain. Brain Res. 82:41-47.
- Kashin, S. M., R. W. Brill, W. N. Ikehara, and A. E. Dizon.
1981. Induced locomotion by midbrain stimulation in restrained skipjack tuna, Katsuwonus pelamis, L. J. Exp. Zool. 216:327-329.
- Yuen, H. S. H.
1966. Swimming speeds of yellowfin and skipjack tuna. Trans. Am. Fish. Soc. 95(2):203-209.

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A NOTE ON THE NUMBER OF FISHING VESSELS IN HAWAII

By

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Recently, in association with attempts by the Western Pacific Regional Fishery Management Council (Council) to prepare a billfish fishery management plan, a question has arisen on whether there has been an increase in domestic fishing effort for billfish (marlins and swordfish) over the period 1979-81. In this note we present some data on the number of vessels in Hawaii as a rough measure of domestic fishing effort.

In cooperation with the Honolulu Laboratory (HL), the Council assembled landing data from select Hawaiian wholesale fish dealers and auction enterprises. These data showed unequivocally that there was a substantial increase in landings of all billfishes combined (34.6%), mahimahi, Coryphaena hippurus, (59.5%), and wahoo, Acanthocybium solandri, (133.2%) over the period 1979-81. The Council's view was that this increase in landings resulted from the cessation of foreign tuna longline fishing within the fishery conservation zone in April 1980 following the implementation of the billfish preliminary fishery management plan.¹ The HL staff maintained that such was not necessarily the case, and that domestic fishing effort statistics would have to be examined to clarify the situation. For instance, the placement of fish aggregating devices by the State in the same year that the plan went into effect may have increased fishing effort and contributed to the increased landings of mahimahi and wahoo.

To provide some information on the subject, we assembled available summaries of the number of vessels documented by the U.S. Coast Guard and registered by the Hawaii Department of Transportation. Because neither documented nor registered vessels are classified in such a manner that commercial fishing vessels can be assigned to specific fishing categories or that "pleasure" boats are used for fishing at all, the data presented below provide only the crudest estimates of fishing effort for billfishes, mahimahi, and wahoo.

The U.S. Coast Guard does not release annual summaries, but they did provide us with an in-house summary covering several years including those for years of interest here (Table 1). For the period 1979 through 1981, the number of vessels increased by 30.1% for commercial fishing vessels, 15.8% for charter fishing vessels, and 13.3% for pleasure vessels.

The Hawaii Department of Transportation does release annual summaries of vessels registered in Hawaii by usage categories (as well as by propulsion, hull material, and type of vessel), and these summaries were used to construct Table 2. For the period 1979-81, there has been an 11.5% increase in commercial fishing vessels, a 20.8% decrease in charter fishing vessels, and a 3.0% decrease in pleasure vessels.

¹Western Pacific Regional Fishery Management Council. n.d. Assessment of changes in the domestic fisheries for select pelagic species based on a survey of major fish dealers and auction houses for 1979, 1980, and 1981. Mimeogr., 12 p.

Table 1.--Number of vessels documented by the U.S. Coast Guard in Hawaii by usage categories. The total is for the three categories given plus passengers, freight, towing, and miscellaneous.

Year	Vessels			Total
	Pleasure	Commercial fishing	Passenger and fishing (including charters) ¹	
1967	176	53	52	416
1977	489	101	122	895
1979	513	113	165	990
1980	574	134	178	1,101
1981	581	147	191	1,141

¹This usage category seems to be entirely charter fishing boats.

Table 2.--Number of vessels registered by the Hawaii Department of Transportation by usage categories. The total includes the three categories given plus commercial passenger, other commercial, livery, dealer, manufacturer, youth group, government and other.

Year	Vessels			Total
	Pleasure	Commercial fishing	Charter fishing	
1971	8,108	364	6	8,803
1972	9,424	430	6	10,250
1973	11,139	519	11	12,049
1974	10,753	582	9	11,843
1975	11,736	683	11	12,956
1976	11,893	760	11	13,130
1977	11,845	826	10	13,165
1978	12,192	929	21	13,695
1979	12,097	1,004	24	13,678
1980	11,785	1,038	17	13,459
1981	11,734	1,119	19	13,405

Table 3.--Number of documented and registered vessels in Hawaii by usage categories.

Year	Vessels			Total
	Pleasure	Commercial fishing	Passenger and fishing (including charters)	
1977	12,334	927	132	14,060
1979	12,610	1,117	189	14,668
1980	12,359	1,172	195	14,560
1981	12,315	1,266	210	14,546

Combining both documented and registered vessels (Table 3), there has been an 8.1% increase in commercial fishing vessels, an 11.1% increase in charter fishing vessels, and a 2.3% decrease in pleasure vessels.

**CHARTLETS OF SELECTED FISHING
BANKS AND PINNACLES IN THE
MARIANA ARCHIPELAGO**

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**ADMINISTRATIVE REPORT H-82-19
November 1982**

The Mariana Archipelago consists of 15 islands, including Guam and Saipan, and numerous small banks, seamounts, and pinnacles. There are a number of charts published by the Defense Mapping Agency (DMA) which provide various degrees of bathymetric detail for the Archipelago (Table 1). Under the direction of the Resource Assessment Investigation of the Mariana Archipelago (RAIOMA) Program of the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory, a bathymetric survey was conducted of islands and banks which are currently being fished or appear to have potential habitat for commercially important marine species, and where the existing bathymetric detail was insufficient for the fisheries assessment work. The primary depth range of interest was 183-915 m (100-500 fathoms). The bathymetric surveys were conducted on the NOAA ship Townsend Cromwell over the period April through August 1982. Depth was determined by an echo sounder and position by loran C. The Townsend Cromwell was under the command of Cdr. Robert C. Roush. The survey work was performed by Cdr. Roush, Lt. James D. Sarb, Lt. Dean L. Smehil, Lt. Gary M. Barone, Lt. Thomas Clark, and Ens. Andrew J. Aldridge.

Table 1.--Defense Mapping Agency charts for the Mariana Archipelago.

DMA No.	Islands
81005	Mariana Islands
81048	Guam
81063	Rota
81067	Saipan, Tinian, Aguijan
81086	Farallon de Pajaros, Sarigan, Farallon de Medinilla, Asuncion, Argihan, Alamagan, Guguan, Anatahan
81092	Pagan, Maug

During the surveys, positions and depths were determined simultaneously at precise 2-1/2 minute intervals, or approximately every 0.4 nmi along the ship's track. A continuous, time annotated analog record (fathogram) of bottom soundings was obtained, and significant bathymetric features, such as peaks or drop-offs, were scaled from the fathograms to supplement the data obtained at the regular 2-1/2 minute sounding intervals. For most of the surveys, the spacing between adjacent sounding lines was approximately 1 nmi. A few randomly spaced crosslines were run across the main lines to provide additional data and to serve as a check on navigational control by comparing soundings obtained at the line intersections.

The Northwest Pacific loran-C chain (SS3, 9970) was utilized with excellent results in most cases for navigational control of the surveys. Satellite position fixes obtained intermittently during the surveys were in close agreement with the loran-C positions. In some instances, loran-C was not available due to low signal-to-noise ratios or because the stations were off the air for maintenance. On these occasions, radar ranges and bearings were used to control the surveys.

Survey data were recorded by hand in a logbook (sounding volume) and also entered manually onto magnetic cassette tapes. Position and depth data were hand-plotted on paper field sheets which in most cases were 1:40,000 scale mercator projections. Following the actual conduct of the survey, printouts from the data cassette tapes were checked for format errors and compared for accuracy with the sounding volumes and rescanned fathograms. An edited data cassette tape, free of format errors, and containing corrections and supplements to the raw data, was then produced. The hand-plotted field sheets were reviewed for accuracy and then redrawn by hand on plastic sheets. The soundings on these sheets were contoured at 100-fathom intervals to show bathymetric detail. Vessel draft corrections of 1.8 fathoms were included in the corrector record on tape, but not applied to the field sheets from which the bathymetric chartlets contained herein were drawn. No corrections to depth were determined or applied for velocity of sound through water variations in instrument initial, belt tension, wave effects, or the vessel's motion while underway.

An overview of the Mariana Archipelago indicating the regions covered in the subsequent chartlets is presented in Figure 1. The chartlets were drawn by Tamotsu Nakata, Honolulu Laboratory scientific illustrator, from the bathymetric boat sheets. Although the attached chartlets are not recommended for use as aids to navigation, these chartlets may be useful to fishermen in identifying the extent and contours of valuable fishing grounds.

Two significant results from this bathymetry work are that the bank area around Farallon de Medinilla is substantially larger than indicated on existing charts and a bank approximately 35 nmi southwest of Guam (Chart No. 9) was charted for the first time.

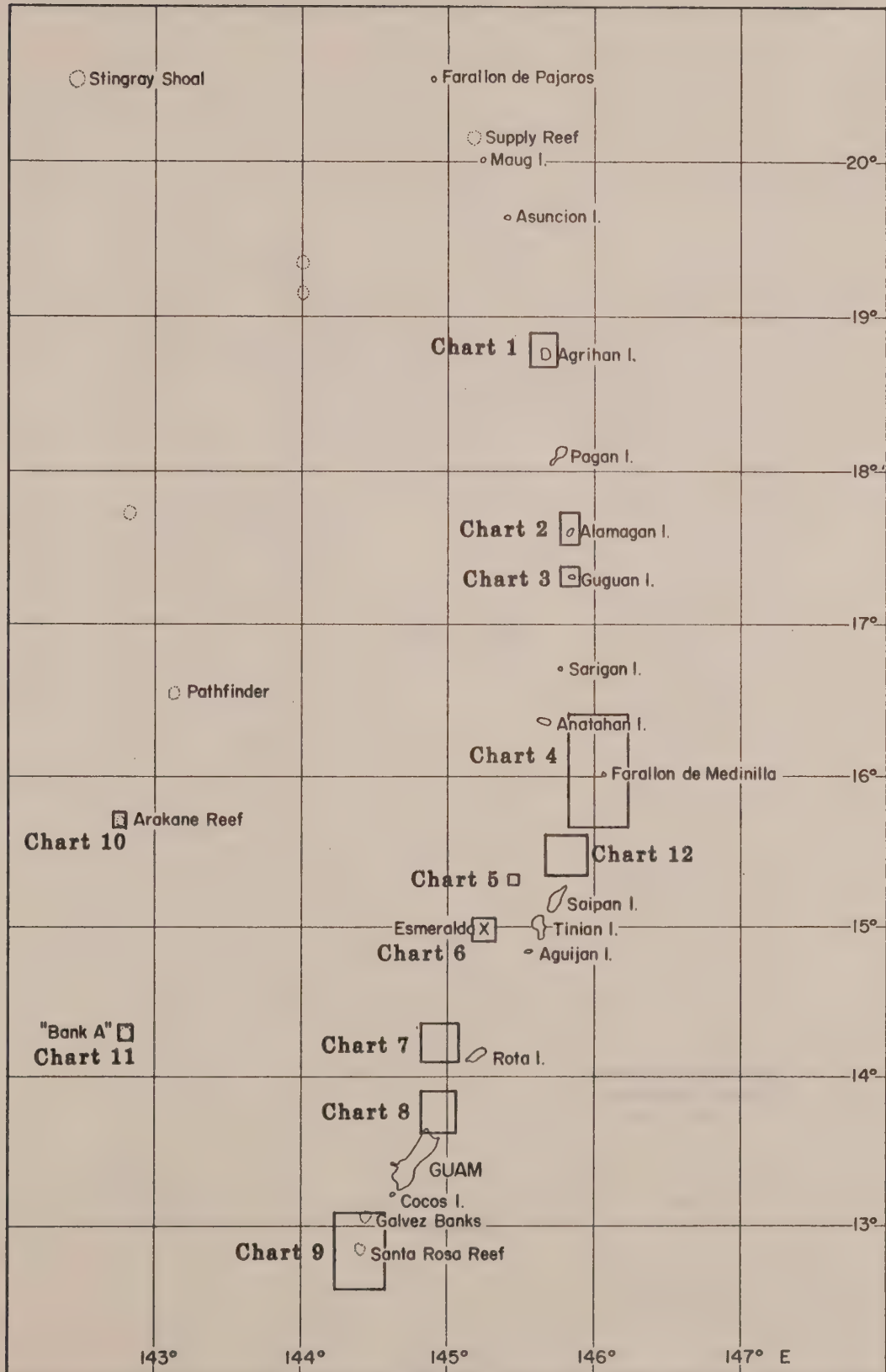


Figure 1

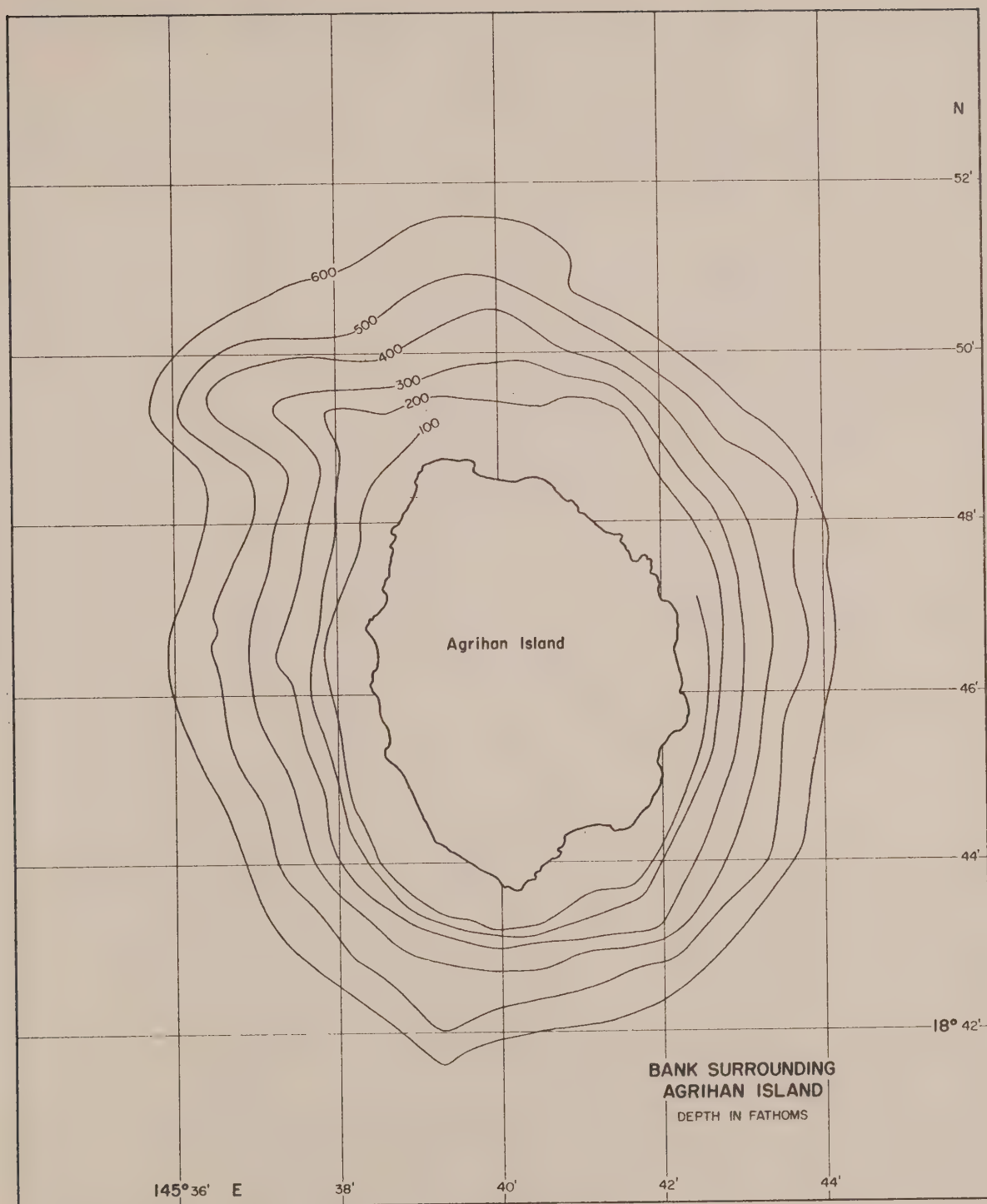


Chart 1

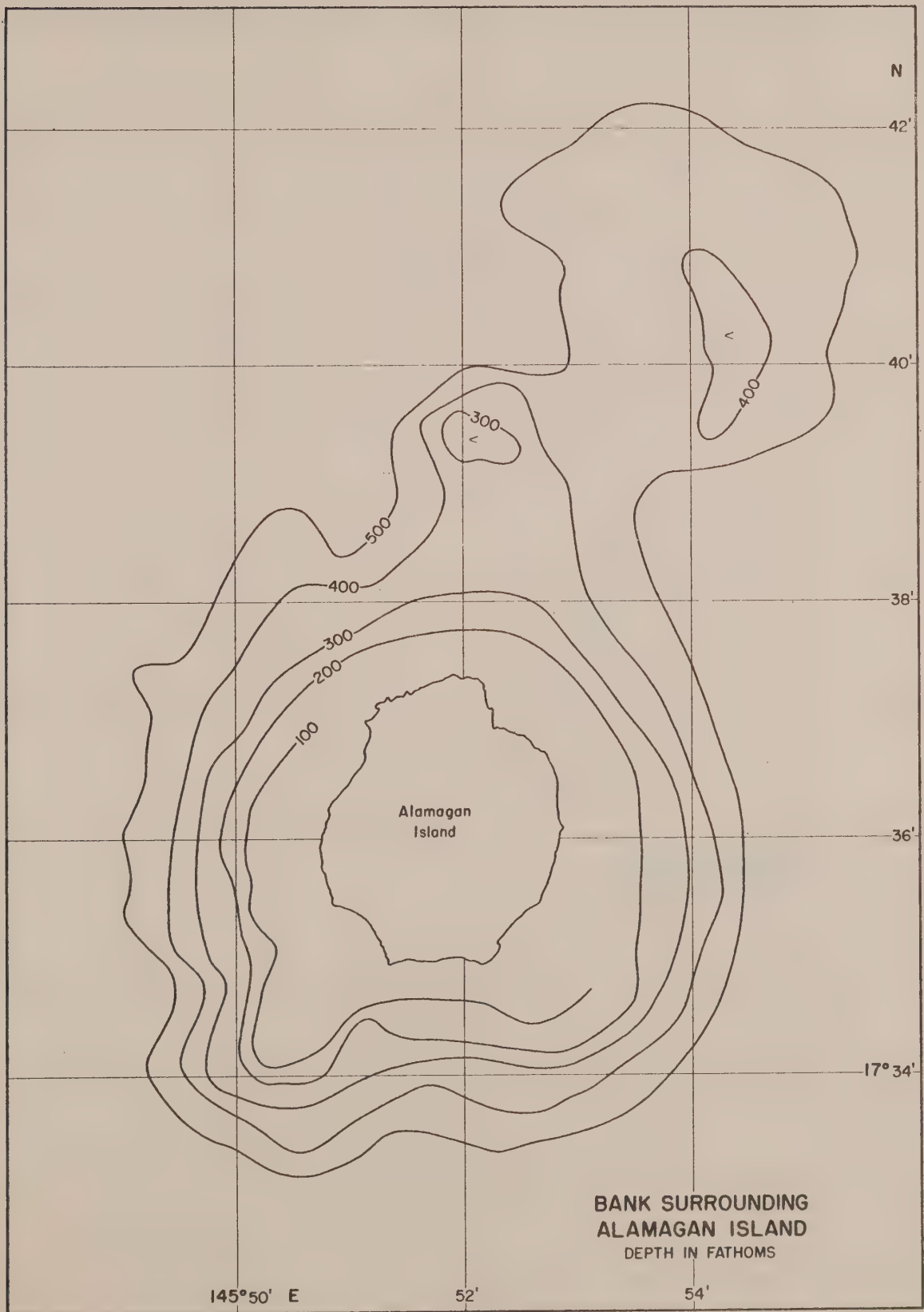


Chart 2

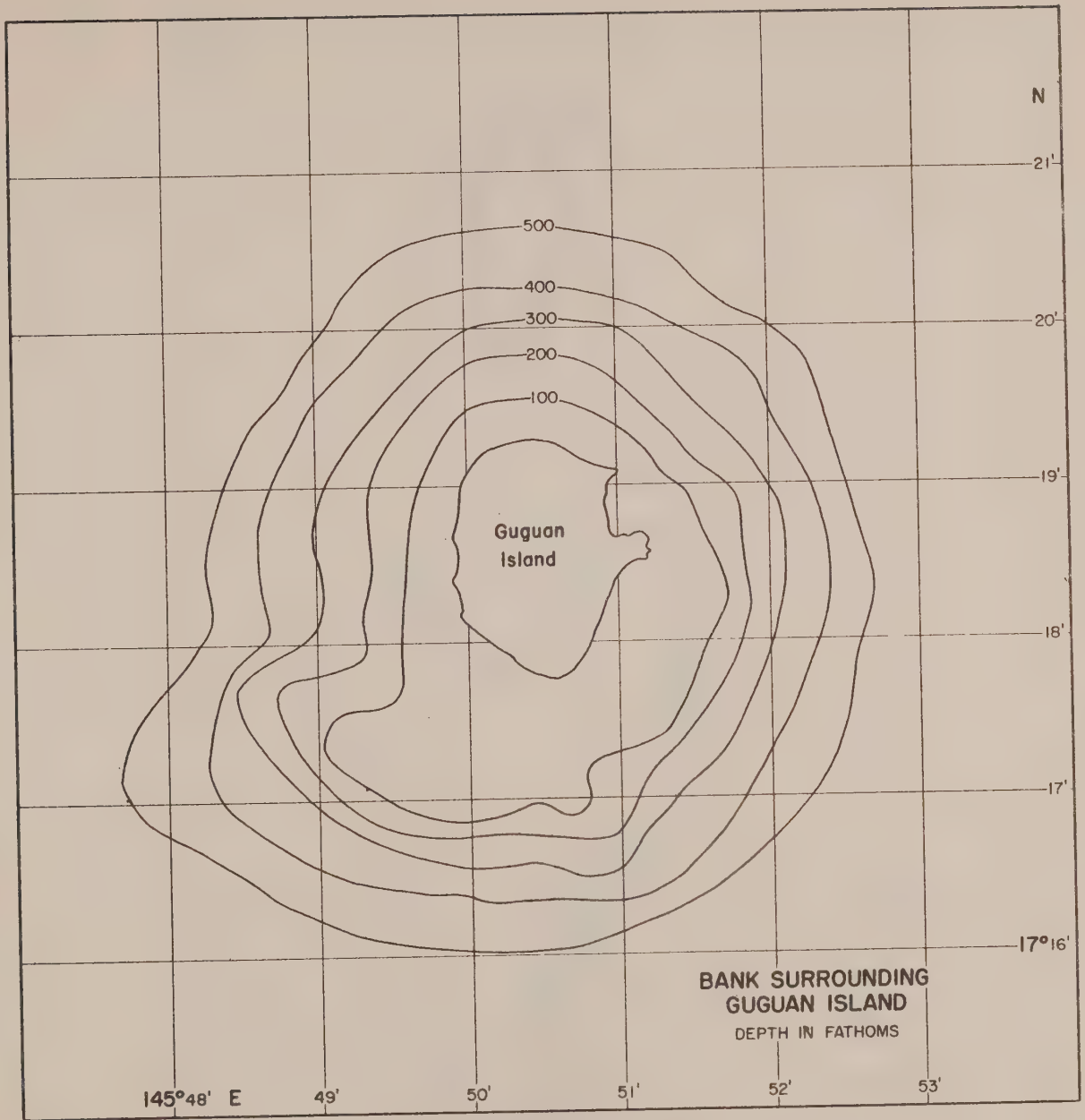


Chart 3

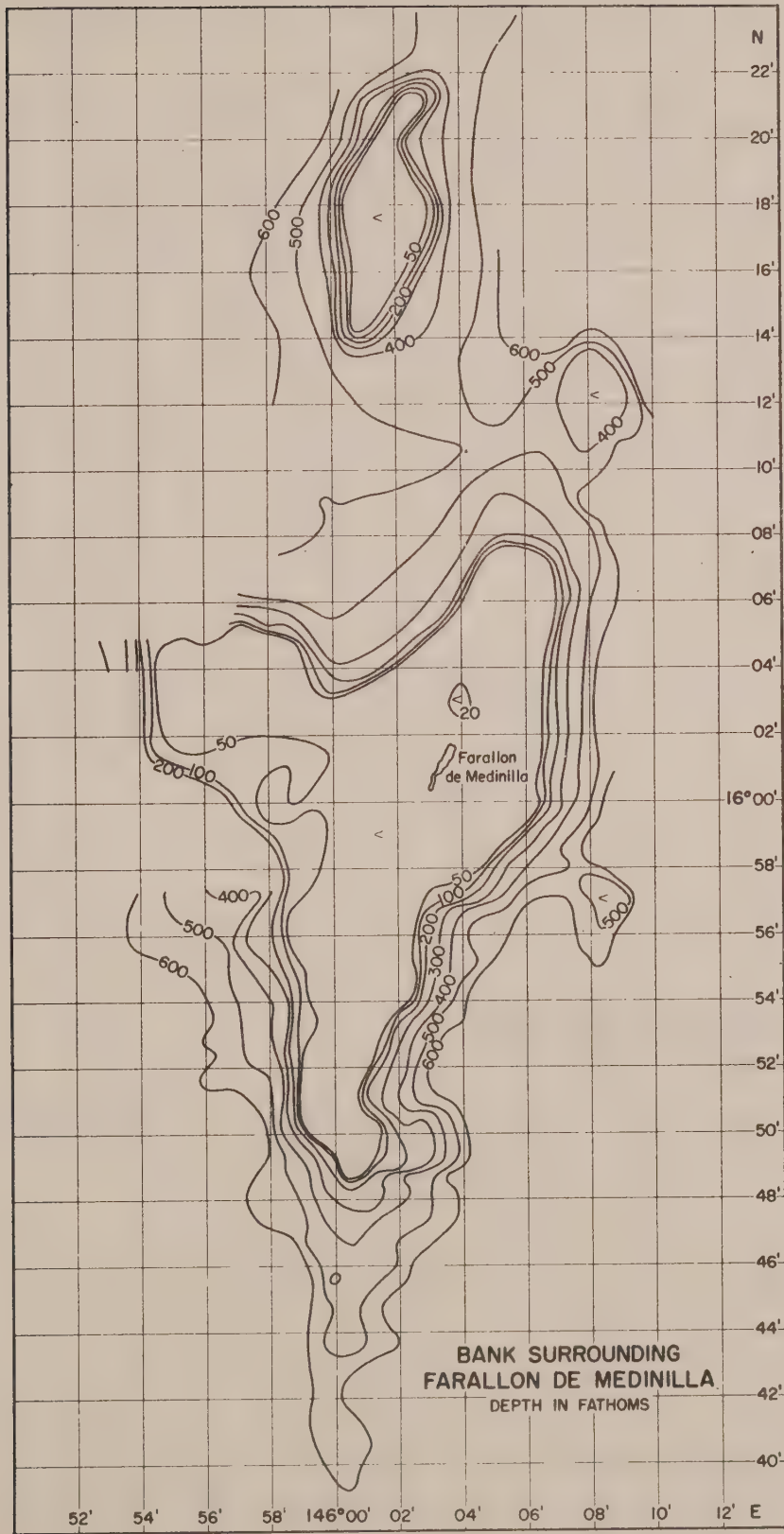


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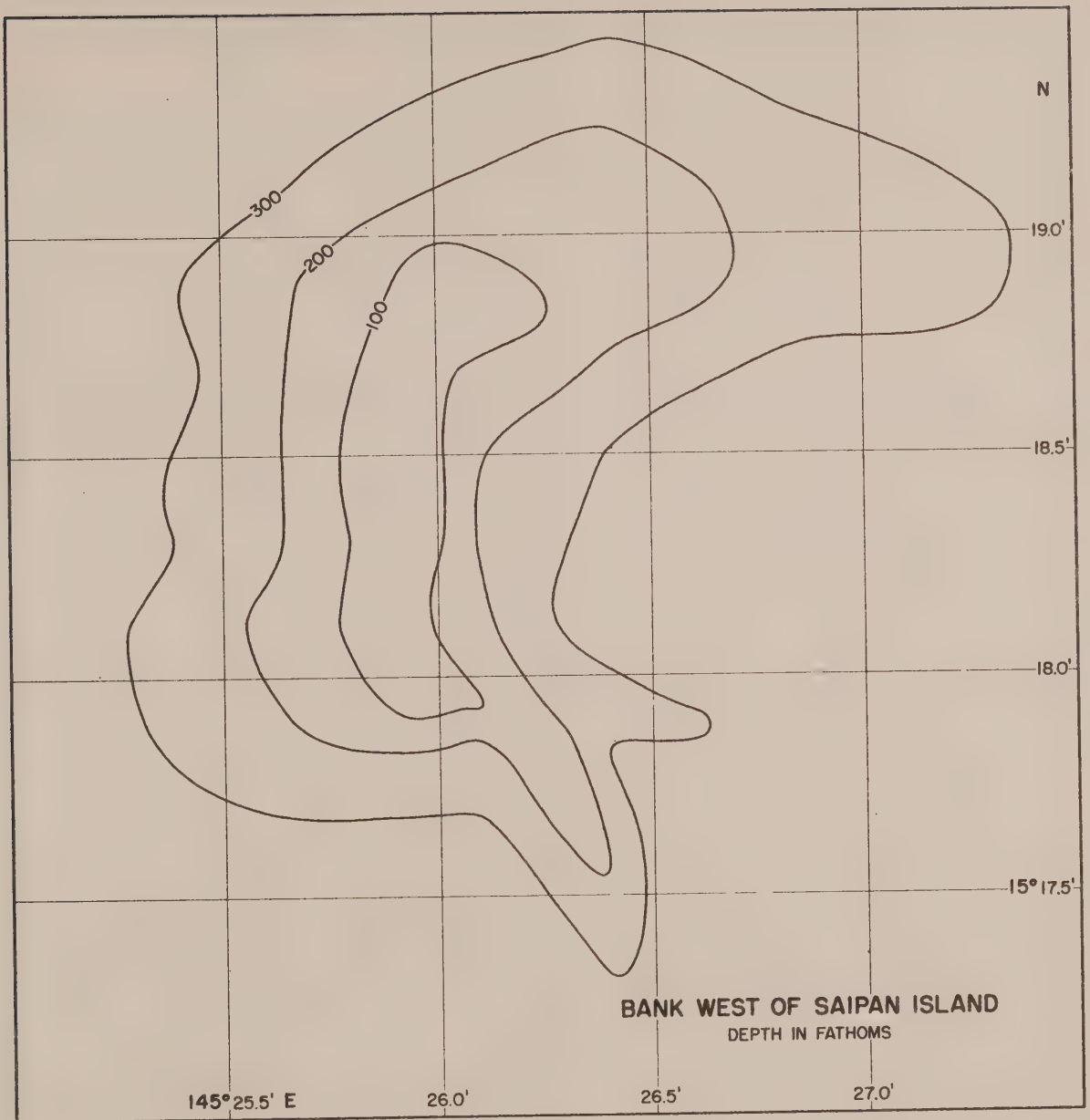


Chart 5

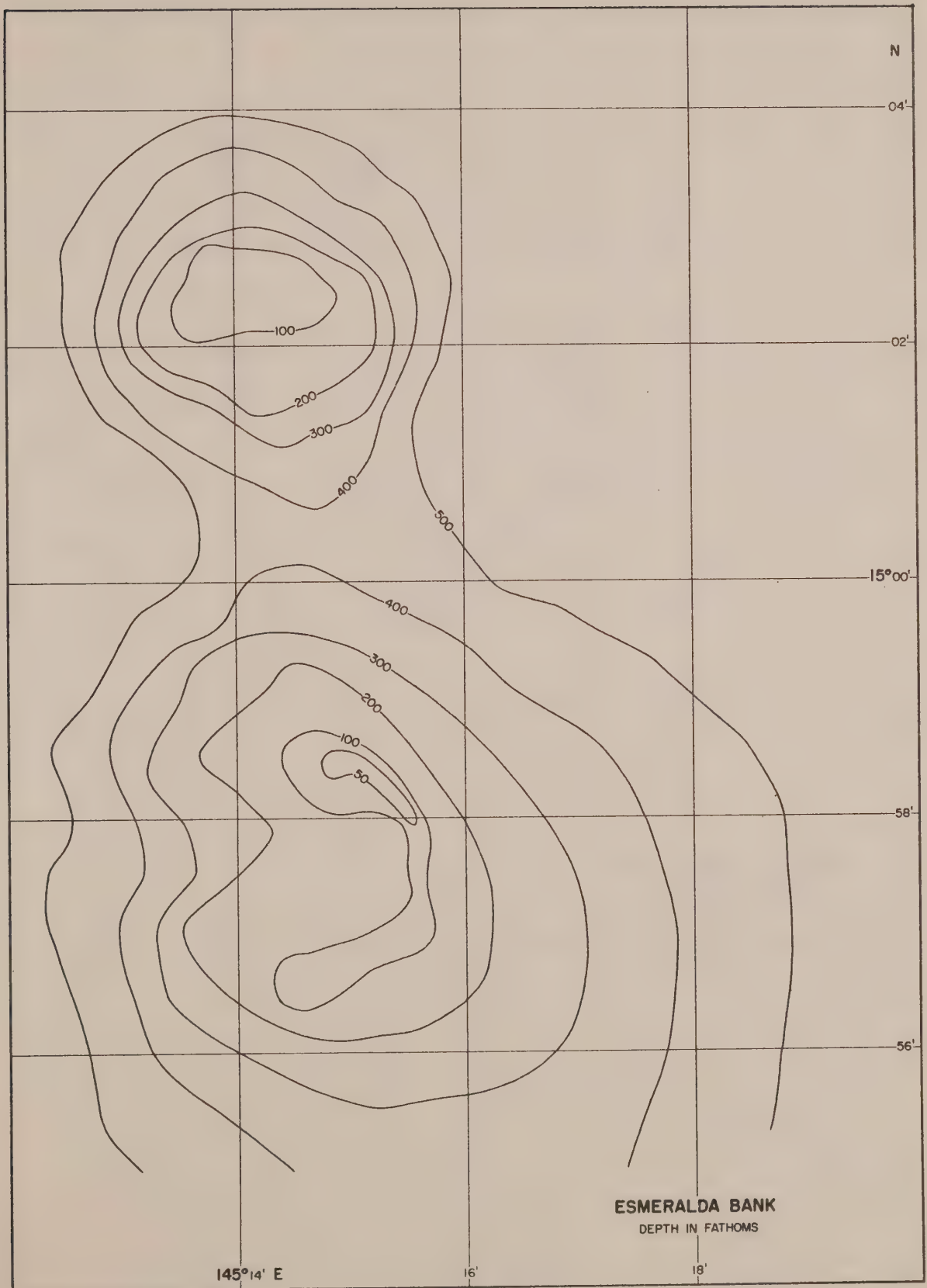


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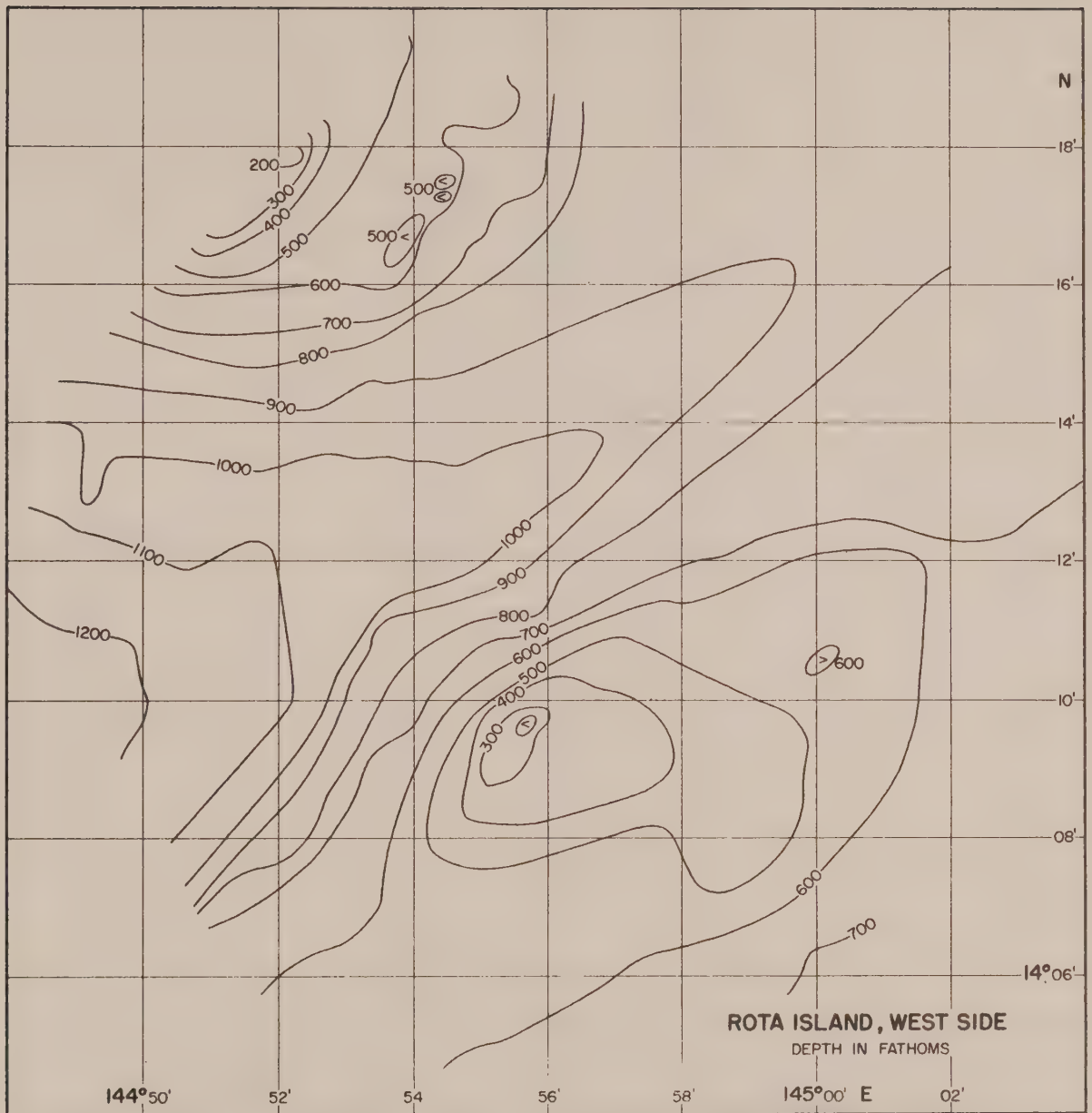


Chart 7

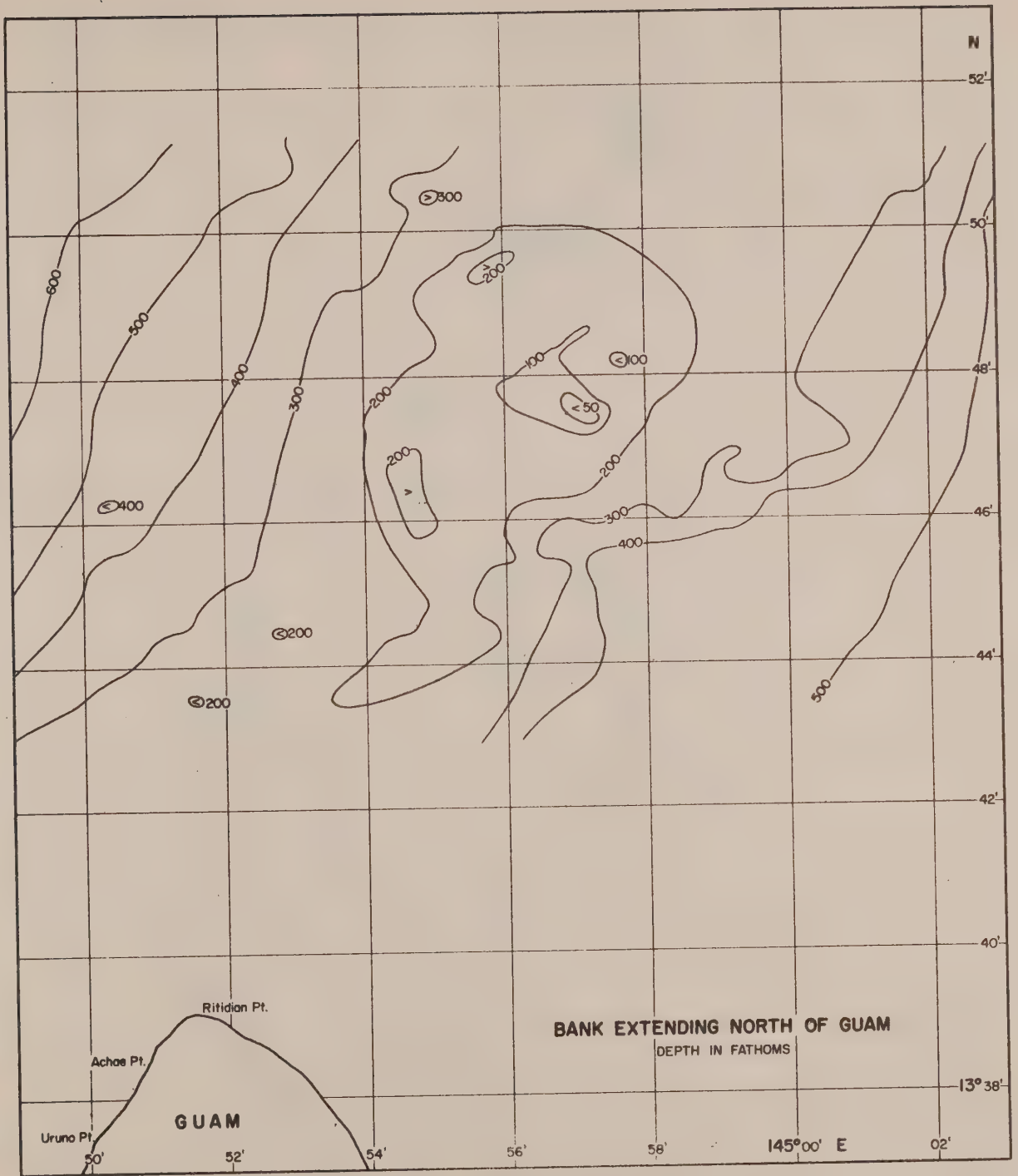


Chart 8

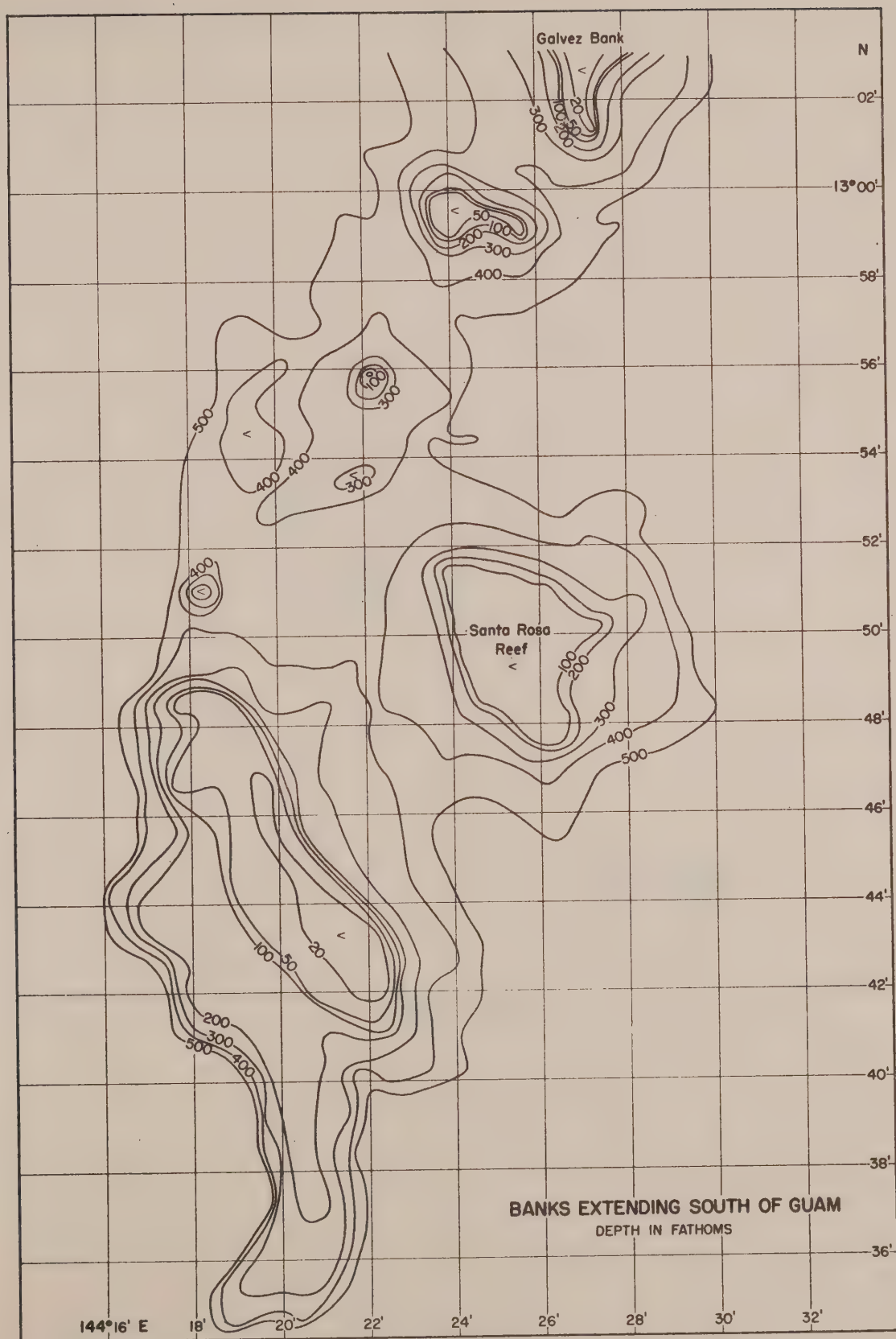


Chart 9

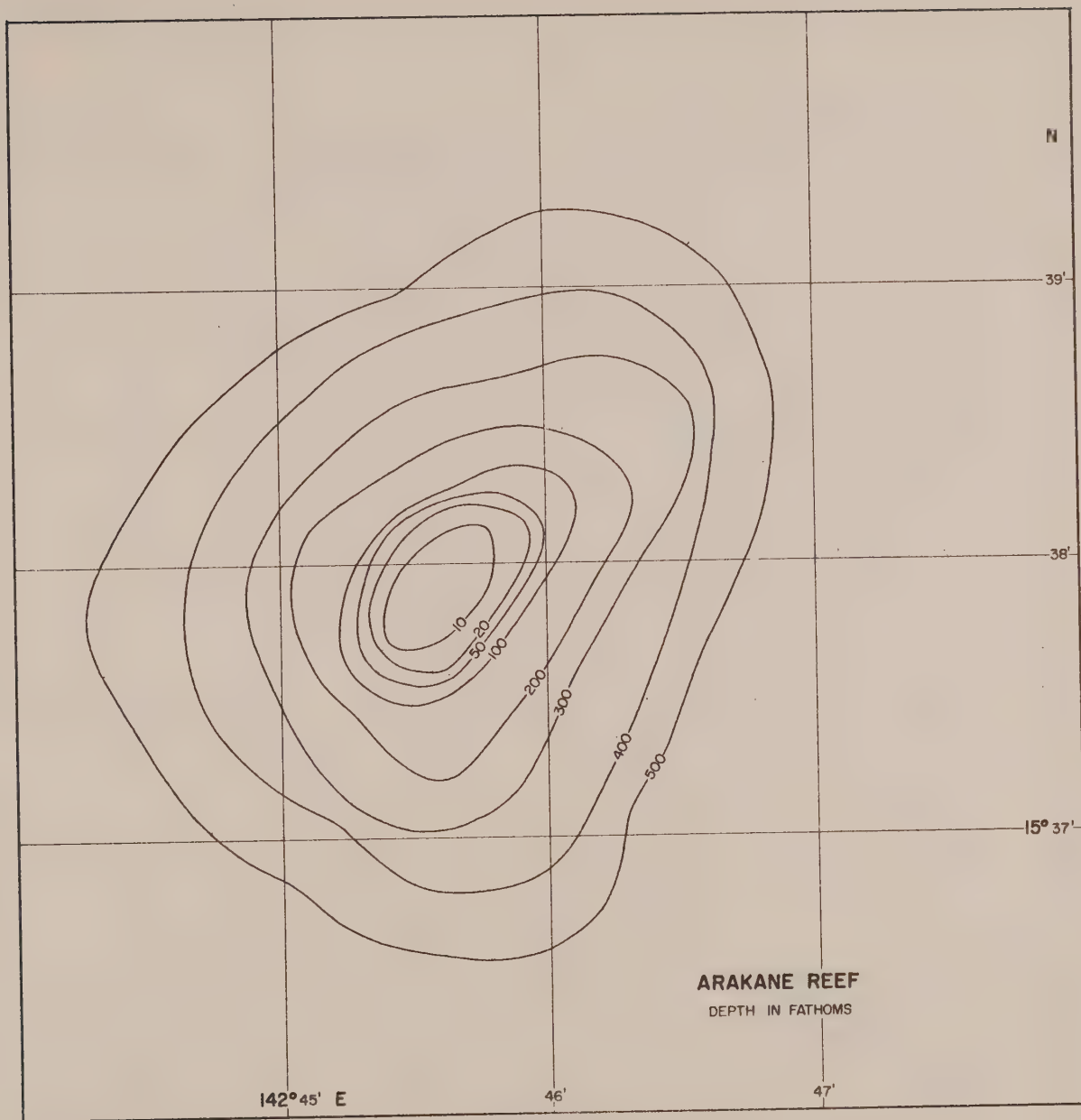


Chart 10

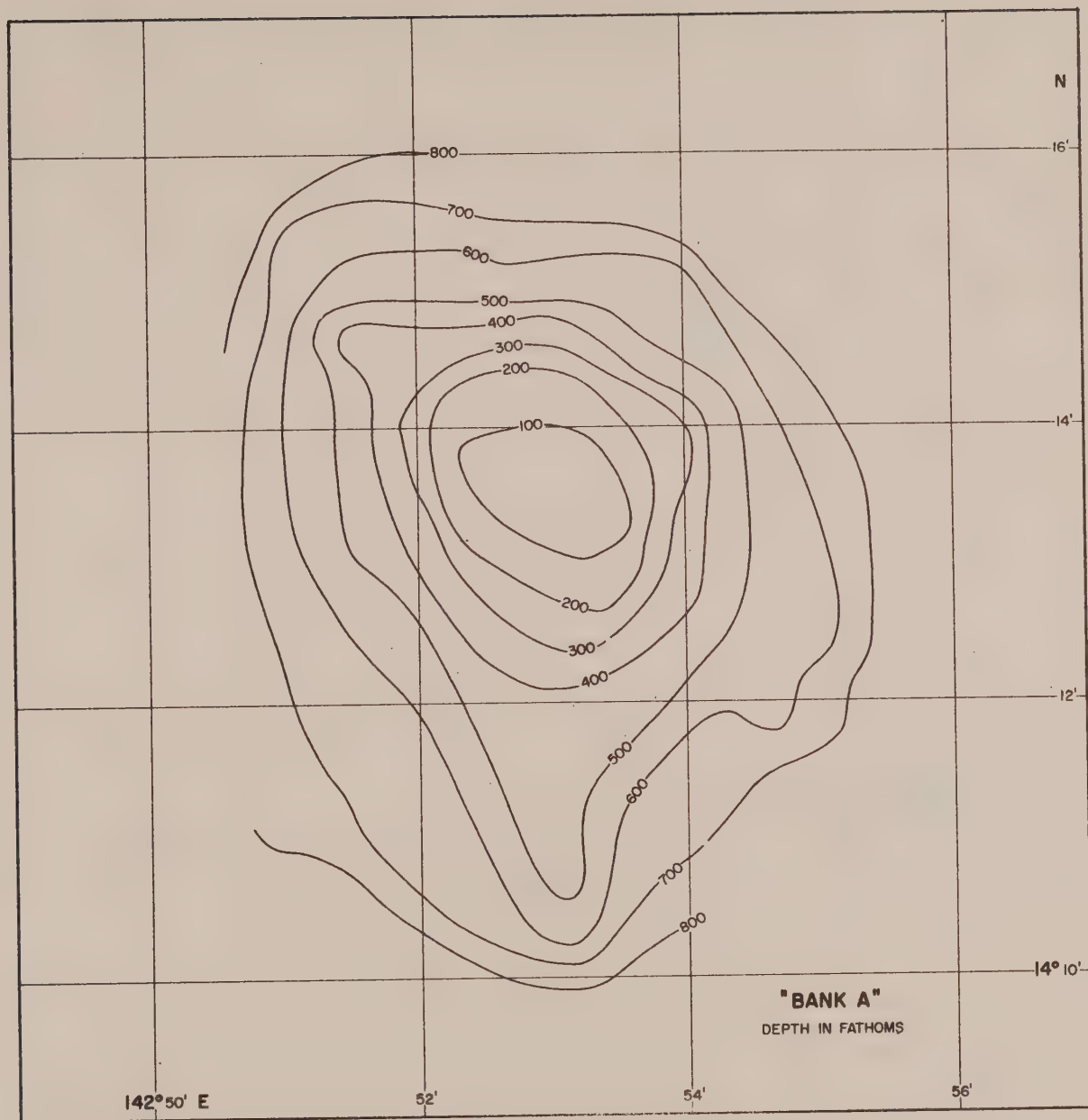


Chart 11

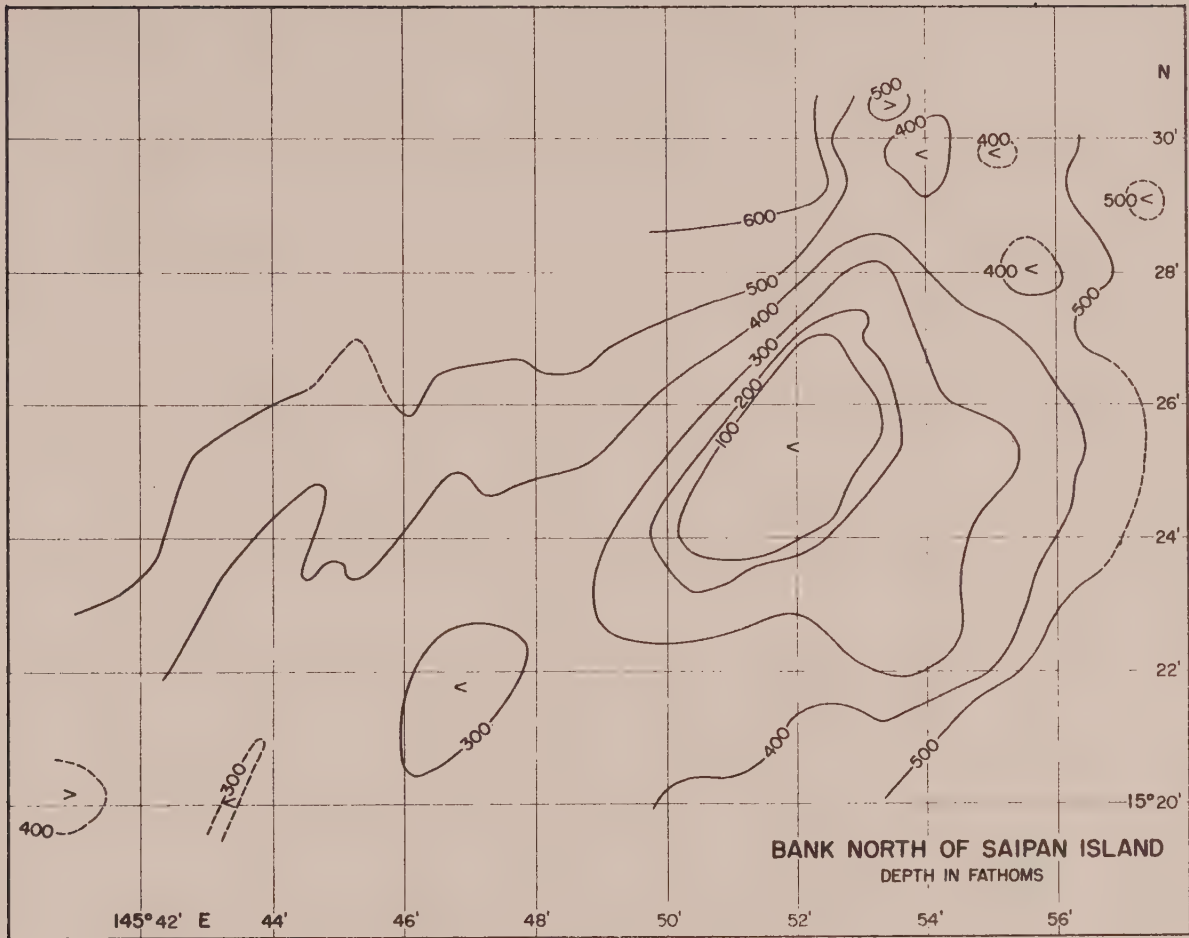


Chart 12

82-20 (rev)



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A NOTE ON THE COMMERCIAL FISHERIES IN HAWAII

By

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ABSTRACT

Commercial fish landings in the State of Hawaii for the 11 most important species are given for 1960, 1970, and 1980. Presented also are brief descriptions of the major fisheries accounting for these landings.

The commercial fish landings for the State of Hawaii have fluctuated between 8,891 metric tons (MT) valued at \$3.6 million in 1965 and 4,400 MT valued at \$6.3 million in 1975. The annual commercial fish landings for Hawaii for the past 20 years averaged 5,942 MT valued at an average of \$5.8 million. The landings are small when compared to those of many other coastal states and contributed but a small portion to the State's income. Although a rich variety of fishes are available, many are not of commercial value. Eleven species comprise over 90% of the State's commercial landings (Table 1). The aku or skipjack tuna, Katsuwonus pelamis, contributed from 40 to 60% of the annual commercial landings.

Table 1.--Landings of some of the important fish species in the Hawaii commercial fishery for 1960, 1970, and 1980 (incomplete data). The 1960 and 1970 figures are from the calendar year reports of the Hawaii Division of Aquatic Resources (HDAR). The 1980 figures are from unpublished data of HDAR. The weights given are for fish actually sold which are usually slightly less than the catch. The totals include the State's landings of all species.

Selected species (Hawaiian name)	1960		1970		1980	
	Catch sold (MT)	Value (\$1,000)	Catch sold (MT)	Value (\$1,000)	Catch sold (MT)	Value (\$1,000)
Skipjack tuna (aku)	3,338	1,001	3,334	1,497	2,486	4,314
Bigeye tuna (ahi)	588	582	216	510	20	83
Yellowfin tuna (ahi)	161	152	320	499	1,241	3,331
Blue marlin (au)	144	90	101	69	203	195
Bigeye scad (akule)	135	207	445	358	232	476
Striped marlin (au)	99	67	156	218	31	72
Mackerel scad (opelu)	87	82	79	98	223	524
Dolphin (mahimahi)	41	50	35	55	111	469
Pink snapper (opakapaka)	40	46	24	40	106	484
Wahoo (ono)	11	6	20	12	121	454
Albacore (ahipalaha)	4	3	9	11	71	127
Total	5,051	2,705	5,127	3,902	5,359	12,255

There were approximately 3,532 licensed commercial fishermen in Hawaii in 1947, and this number declined to a low of 715 in 1966 (Hawaii State. Department of Land and Natural Resources 1979). Since then, the number of fishermen has risen steadily, and today there are about 2,500 licensed commercial fishermen in the State. In 1970, there were about 80 vessels of 5 net tons or larger fishing commercially in Hawaiian waters and less than

700 smaller commercial fishing boats (Hawaii State. Department of Land and Natural Resources 1979). In 1980, there were over 130 fishing vessels larger than 5 net tons and over 1,000 smaller fishing boats.

Much of the fishing is done within 20 nmi of the main islands, and the fishing techniques, vessels, and equipment have changed but little in the past 50 years.

The Skipjack Tuna Fishery

The live-bait, pole-and-line skipjack tuna fishery is the most important fishery in terms of weight landed and value of catch. In 1965, 7,348 MT of skipjack tuna were landed which was worth \$2 million. More recently, the catches have fallen below 2,722 MT in 1979 and 1980. The price of tuna, however, has improved over the years as indicated by the value of \$4.3 million for the 2,495 MT of skipjack tuna landed in 1980. The skipjack tuna fishery is seasonal with the greatest landings being made from about May through September. There were 32 skipjack tuna fishing vessels operating in 1948, whereas today there are only 13 vessels. The vessels range in length from 15.2 to 27.4 m. A steel 27-m vessel built in 1971 and a 22.8-m fiberglass vessel built in 1979 are the only new additions to the fleet that is otherwise made up of boats 25 years and older. The average vessel crew is 10, and there are about 130 full-time fishermen in this fishery.

A readily available and suitable baitfish is essential to this fishery. The most important baitfish is the nehu, Stolephorus purpureus, an anchovy. About 30,000 to 40,000 buckets (one bucket = 5 kg) are caught annually by the skipjack tuna fishing fleet mostly in Pearl Harbor, Kaneohe Bay, and Keehi Lagoon.

Because the nehu is relatively weak, fishing is primarily confined close to the main islands, and typically, a fishing trip lasts a day. Crushed ice is carried aboard the vessels to refrigerate the catch.

Several efforts over the last 24 years have been made to find suitable supplementary baitfish. In cooperation with Hawaii Division of Aquatic Resources (HDAR), eight batches of the Marquesan sardine, Sardinella marquesensis, which seemed like a good baitfish, were brought to the Honolulu Laboratory and released around Oahu from 1955 to 1959. Although the sardine became established in the islands, its use as baitfish has been very limited. The Honolulu Laboratory carried out a pilot study on the Island of Maui in 1958-59 to produce tilapia, Tilapia mossambica, as supplemental live bait. The results were encouraging and the State built a prototype hatchery. However, skipjack tuna fishermen preferred to use the native nehu rather than the tilapia, and the State's operation was abandoned. In cooperation with HDAR the Honolulu Laboratory also transported threadfin shad, Dorosoma petenense, from California for introduction into Lake Wilson in August 1959. The threadfin shad became established within a year, and shortly thereafter many sea trials were made using them as live bait. Although they were found to be a suitable live bait, there were problems in transporting them from Lake Wilson to the vessels, mortalities were high,

and the skipjack tuna fishermen again preferred nehu to shad. In 1975 the Honolulu Laboratory undertook to transport northern anchovy, Engraulis mordax, from California to Honolulu. Not only were there problems in developing an effective means of transportation, but the fishermen again preferred the endemic bait. Topminnows, especially of the genus Poecilia, have been used at times by Hawaiian skipjack tuna fishermen as live bait. Some studies in production and sea tests for suitability were carried out by personnel of the Hawaii Institute of Marine Biology in the 1970's. Presently studies are underway to raise topminnows, mullet, and milkfish as baitfish by the State of Hawaii, Maui County, and the Pacific Tuna Development Foundation in a joint undertaking.

The Tuna Longline Fishery

The tuna longline fishery once occupied a prominent position in Hawaii's fishery. There were about 33 longline fishing vessels based in Honolulu and 10 based in Hilo during 1949-52 (Otsu 1954). The vessels ranged in length from 12.2 to 19.2 m. The annual landings during 1953-54 reached a high of 1,996 MT. The bigeye tuna, Thunnus obesus, landings were as high as 1,270 MT in 1953 and yellowfin tuna, T. albacares, landings were as high as 862 MT in 1952. Based upon four fishermen aboard each vessel, there must have been over 150 full-time commercial fishermen in the fishery during those years. The number of vessels remained fairly constant up to 1957 before showing signs of decline. Presently, the fleet consists of 18 vessels; a few of them, about 24 m long, are new to the fishery. Recently, the catch of bigeye tuna made in this fishery amounted to only 79 MT and that of yellowfin tuna amounted to only 84 MT. Even with the inclusion of the blue marlin, Makaira indica, and striped marlin, Tetrapturus audax, wahoo, Acanthocybium solandri, mahimahi, Coryphaena hippurus, and albacore, T. alalunga, that are caught in this fishery, the most recent figures extracted from the 1979 commercial fish landings records of the State of Hawaii gave a total landing of 117 MT. Most of the fishing is done within 100 nmi of the main islands, but some of the vessels fish up to about 500 nmi from the islands.

The catches from this fishery are brought back chilled and sold fresh, mostly to the sashimi market. Some tuna of poorer quality are sold to the cannery, and some of the marlins and tunas make their way into the fishcake market. Prices have increased and sashimi quality tunas command very high prices, e.g., \$11.00/kg (\$5.00/lb) in the round.

The Ika-Shibi Fishery

The Hawaiian ika-shibi fishery had its beginning as a squid fishery early in the 1900's when Japanese immigrants began handlining for squids from small boats (Yuen 1979). World War II curtailed the fishery; then after the War, three to four boats resumed the fishery in which tunas are caught incidental to squid fishing. By 1976, this night handline fishery, concentrating its effort on tunas, had grown to about 30 boats. A wide assortment of boats is used in this fishery. They range from 6.1-m fiberglass skiffs to 18.3-m vessels that fish tuna longlines during the off-season. The boats are usually manned by two men, but some fishermen go out alone. Three heavy handlines are usually fished from a boat: one each at

the bow, midship, and the stern. The fishing grounds are about 15 to 20 nmi from port, and the boats leave port in time to reach the fishing grounds at sundown. They use a sea anchor to slow down their drift, turn on two lights above surface and one light underwater, and start fishing for squids. They fish for tunas after enough squids are caught. However, they may fish for tunas simultaneously while fishing for squids. In areas where squids are scarce, they fish for tunas only with frozen bait.

There are an estimated 250 boats fishing, and assuming that there are 2 fishermen on each boat, there should be about 500 fishermen in this fishery. The fishing is primarily conducted off the Island of Hawaii, especially to the east of Hilo, off South Point, and to the west of Kailua-Kona. Seasons differ with area: July through December on the east side of the island and January through April on the west side. Most of the productive areas are within 20 nmi of shore. The catch is primarily sent to the fresh fish (sashimi) market. A large portion of the catch is thought to be exported, mostly to the mainland and some to Japan although no statistics are available to document the volume. In 1980, the average ex-vessel price per kilogram for yellowfin tuna was \$3.22 (or \$1.46/lb) and that for bigeye tuna was \$3.75 (or \$1.70/lb). Marlins, swordfish, Xiphias gladius, albacore, mahimahi, and a few other species are also caught in this fishery. The most recent catches made by this fishery are given in Table 2.

Table 2.--Ika-shibi landings in Hawaii, 1980 (Ikehara 1982¹).

Species	Weight (MT)	Value (\$1,000)
Yellowfin tuna	813	2,619
Albacore	44	71
Bigeye tuna	29	109
Swordfish	20	59
Mahimahi	7	33
Marlins	8	15
Squids	2	4

¹Ikehara, Walter N. 1982. A survey of the ikashibi tuna fishery in the State of Hawaii. Southwest Fish. Cent. Adm. Rep. H-82-4C, 12 p., Southwest Fish Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, Hawaii 96812.

The Troll Fishery

The landings of the State's commercial troll fishery totaled 37 MT valued at \$18,000 to the fishermen in 1960. This was <1% of the State's commercial fish landings of 5,034 MT valued at \$2.7 million to the fishermen. Blue marlin contributed the largest percentage of the commercial troll landings followed by skipjack tuna, yellowfin tuna, wahoo, mahimahi, and striped marlin (Table 3).

In recent years with the increased number of commercial charter (trolling) vessels and the placement of fish aggregating devices by the HDAR, there were significant increases in the commercial troll landings. Also in recent years, several albacore trolling vessels from the west coast, fishing for albacore in waters north of Midway Islands and also for yellowfin tuna and wahoo in the Northwestern Hawaiian Islands (NWHI), have landed their catches in Hawaii.

Roughly 200 vessels and 240 fishermen indicated that they trolled commercially and about 1,000 vessels and 1,000 fishermen indicated that they fished commercially combining trolling with other types of fishing during fiscal year 1981-82 (license forms issued by the Hawaii Division of Conservation and Resources Enforcement).

The commercial troll-caught landings totaled 807 MT valued at \$2.1 million to the fishermen in 1981 (incomplete landing data from HDAR). This was 33% of the State's commercial fish landings of 2,465 MT and 37% of the value of the State's commercial fish landings of \$5.7 million. Yellowfin tuna contributed the largest percentage to the commercial troll landings followed by the blue marlin, wahoo, mahimahi, albacore, skipjack tuna, and striped marlin (Table 3).

Table 3.--Landings of major species caught in the Hawaiian troll fishery for 1960 and 1981.

Species	1960		1981	
	Weight sold (MT)	Value (\$1,000)	Weight sold (MT)	Value (\$1,000)
Blue marlin	17	6	178	220
Skipjack tuna	5	3	28	64
Yellowfin tuna	5	3	248	784
Wahoo	2	1	92	413
Mahimahi	2	1	71	385
Albacore	--	--	55	151
Striped marlin	1	1	10	27

The Spiny Lobster Fishery

The commercial spiny lobster fishery in Hawaii was very small up until the mid-1970's when an exploitable resource was found in the NWHI by the Honolulu Laboratory. In 1960, the commercial landings amounted to only 4.5 MT, valued at about \$7,000; in 1970 the landings totaled a little over 2.3 MT, valued at about \$6,000. In 1977 there was a dramatic increase in the landings due primarily to the expansion of the fishery to the NWHI. In

1981, it was estimated that the landings in the NWHI fishery exceeded 317.5 MT, valued at over \$3 million (Ito¹), and for January-September 1982, the catch was estimated to be 25 MT. The catch consists primarily of Panulirus marginatus and a small percentage of P. penicillatus.

Lobster fishing around the main islands is confined to shallow waters where several methods of capture are used. Panulirus marginatus and P. penicillatus are caught incidentally in fish traps, gill nets, and by divers who catch them by hand. Recent landings have not exceeded 7 MT and have averaged only about 3.5 MT. It is generally believed that the recreational catch of spiny lobsters around the main Hawaiian Islands is greater than the commercial catch.

Five vessels are currently fishing for spiny lobsters in the NWHI. In 1981, there were nine vessels, ranging in length from 18.3 to 55.5 m. Some of the vessels were from the king crab and black cod fisheries of the U.S. west coast and others were from the albacore fleet in Honolulu. Most of the vessels use the California two-chambered, lobster pot (0.5 x 0.8 x 0.9 m). Frozen mackerel is usually used for bait. The vessels usually carry 250 to 300 traps. One boat carried 2,000 pots. There are 6 crewmen on the smaller boats and 18 on the largest.

The two primary areas fished for lobsters in the NWHI are Necker Island and Maro Reef. The best concentrations of lobsters have been found between 27 and 55 m around Necker Island and Maro Reef.

Since there is a limited market for live lobsters in Hawaii, much of the marketing in 1981 was directed at the frozen tail market. It is believed that some of the catches are exported to Japan and the United States mainland.

In the State of Hawaii, the legal size for spiny lobsters is presently 8.25 cm carapace length. All berried females must be released, and open fishing season is from September 1 through May 30. The season is closed from June 1 through August 31 when a high percentage of females are said to be berried. A Fishery Management Plan has been developed by the Western Pacific Regional Fishery Management Council for spiny lobsters in the U.S. Fishery Conservation Zone (FCZ) in the western Pacific which is primarily in the NWHI. The plan has been approved and regulations, including a minimum carapace length of 7.7 cm or tail width of 5.0 cm, when the carapace has been removed, have been proposed for the FCZ around the NWHI. In addition, the Council has recently proposed implementing regulations for the FCZ around the main Hawaiian Islands and one of the options essentially duplicates the State regulations. Implementation of the regulations is being delayed because of consistency of issues relative to the interpretation of the Coastal Zone Management Program.

¹Ito, Bernard M., Physical Science Technician, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, P. O. Box 3830, Honolulu, HI 96812, pers. commun.

The Bigeye Scad (Akule) Fishery

The bigeye scad (akule), Selar crumenophthalmus, is a relatively important species in the Hawaii fisheries. It is a very popular fish that is consumed fried, dried, and in many other ways. The annual landings of this species approached 136 MT, valued at \$207,000, in 1960. In 1970 the landing increased to nearly 454 MT, valued at about \$360,000. The catch declined in 1980 to about 227 MT, valued at almost \$500,000.

Available data show that in 1979 roughly 47% of the akule were caught with bag nets, 23% with handlines, and 30% with gill nets. In 1965 the situation was a little different; 69% were caught with bag nets, 29% with handlines, and only 2% with gill nets. The dramatic increase in gill net caught fish in recent years probably resulted from the use of monofilament gill nets.

The Mackerel Scad (Opelu) Fishery

The mackerel scad (opelu), Decapterus macarellus, like the akule, is a very popular fish that is consumed in a variety of ways including fried, dried, etc. The landings of this species in the 1960's and 1970's remained below 90.7 MT annually and were valued at less than \$100,000. More recently, the landings have increased, approaching 227 MT and were valued at more than \$500,000.

In 1979, roughly 51% were caught with handlines and 48% with lift nets. In 1965, about 56% were caught with handlines and 44% with lift nets.

The Pink Snapper (Opakapaka) Fishery

The pink snapper (opakapaka), Pristipomoides filamentosus, is a very popular species with wide ethnic appeal and strong demand in the restaurant trade because of its fine flesh quality.

The landings in 1960 amounted to 40 MT, valued at \$46,000. In 1970, the landings declined to 24 MT, valued at \$40,000. The landings increased in 1980 to 101 MT, valued at \$484,000. This species is caught almost wholly using handlines.

Other Important Species in the Handline Fishery

The jacks or ulua (Carangidae), are the most prominent of the remaining commercial species. Although the landings are composed of more than a single species, we believe that they are mostly Caranx ignobilis. They are consumed raw as sashimi, fried, baked, etc. In 1980, the landings amounted to nearly 27 MT valued at \$146,000.

The gray snapper (uku), Aprion virescens, is utilized in much the same manner as the ulua. The 1980 landings amounted to 34 MT, valued at \$161,000.

The blue-lined snapper (taape), Lutjanus kasmira, which was introduced from the Marquesas Islands and Moorea into Hawaiian waters by the Hawaii Division of Fish and Game (now HDAR) between 1958 and 1961 quickly established itself in the islands. It is a nearshore species making it vulnerable to capture by fishermen using quite small boats. They are good for panfrying and broiling. The 1980 landings amounted to 28 MT, valued at \$32,000.

The grouper (hapuupuu), Epinephelus quernus, the red snapper or onaga, Etelis coruscans, and ehu, E. carbunculus, and the amberjack (kahala), Seriola dumerili, are some of the other important handline species. They are consumed in many different ways. The onaga is one of the most highly esteemed fish and is used widely as a centerpiece on festive occasions. Collectively, these species contributed 72 MT to the landings with a value of \$222,000.

Miscellaneous Species

The goatfishes (weke), mostly Mulloidichthys spp., are caught by various gear such as gill nets, traps, and handlines in shallow water. They are rather strong flavored and do not command prime prices. In 1980, roughly 29 MT were caught and were valued at \$51,000. They are mostly consumed fried or broiled.

The kawakawa, Euthynnus affinis, a small coastal tuna, is caught by trolling. In 1980, the total catch was a little more than 26 MT and was valued at slightly more than \$34,000. It does not command high prices and is commonly used in a diced raw fish dish called "poke." It is also fried or dried, but it is definitely not used for canning because of its dark-colored flesh.

Squirrelfishes (uu), Myripristis spp., are caught handlining, spear-
ing, netting, and trapping. They are usually consumed fried but are known to make a good soup. The landings totaled 19 MT, valued at \$75,000, in 1980.

Statistical Information on Commercial Fishermen and Vessels in Hawaii

Although it is traditional to analyze fisheries by gear types or species, it is difficult to do so in Hawaii because of the nature of the fisheries. Most of the Hawaiian fishermen are multigear and multispecies fishermen. They use several types of gear to target on different species or species groups; sometimes on the same trip, sometimes during different seasons. There are some who fish with one type of gear throughout the year, e.g., the skipjack tuna live-bait, pole-and-line fishermen, tuna longline fishermen, some handline fishermen, and some troll fishermen. Although fishing with one type of gear, they may catch as many as a dozen different species of fish. In addition, availability of certain species, weather conditions, and market conditions all play a part in determining the type of fishing that is carried out.

Therefore, it is very difficult to classify fishermen and fishing vessels by type of fishing. Indeed, it is difficult for the fishermen to do so as can be seen from the records of Hawaii Division of Conservation and Resources Enforcement. When completing the application for a commercial fishing license, the fishermen check off as many as five or six different types of fishing. The tabulation of numbers of fishermen and vessels by each different combination of fishing types, as indicated on the license forms of the Hawaii Division of Conservation and Resources Enforcement, results in an unwieldy classification summary totaling in excess of 100 categories of fishing types.

LITERATURE CITED

Hawaii State. Department of Land and Natural Resources.

1979. Hawaii fisheries development plan. Department of Land and Natural Resources, State of Hawaii, 297 p.

Otsu, T.

1954. Analysis of the Hawaiian longline fishery, 1948-52. Commer. Fish. Rev. 16(9):1-17.

Yuen, H. S. H.

1979. A night handline fishery for tunas in Hawaii. Mar. Fish. Rev. 51(8):7-14.



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SEAMOUNT TRAWL FISHERY IN THE FISHERY CONSERVATION ZONE,
FOREIGN VESSEL OBSERVER REPORT, ASO MARU
(SEPTEMBER 18-26, 1982)

By

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NOVEMBER 1982

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The open season for foreign groundfish trawlers operating inside the U.S. Fishery Conservation Zone (FCZ) of the central Pacific runs from May 1 to October 1. During this period in 1982, there were three separate trawling operations conducted in the FCZ around Hawaii, all by Japanese stern trawlers owned and operated by Nippon Suisan Kaisha, Ltd. of Tobata, Kitakyushu, Japan. This report covers the third and final fishing period of this season (Table 1).

Table 1.--Summary of 1982 seamount trawl catches for all vessels in the central Pacific FCZ.

Vessel	Date	Catch (metric tons (MT))			
		Armorhead	Alfonsin	Other	Total
<u>Takachiho Maru</u>	May 3-17 (14 days)	243.5	13.8	10.2	267.5
<u>Aso Maru</u>	July 17-Aug. 10 (15 days)	25.5	61.7	17.2	104.4
<u>Aso Maru</u>	Sept. 18-26 (9 days)	8.3	5.0	7.8	21.1
Total all vessels	(38 days)	277.3	80.5	35.2	393.0

The Aso Maru (Table 2) began the 1982 seamount trawling season at the Emperor Seamounts outside the FCZ, and then moved inside for a period of 15 days fishing at Hancock Seamounts (Figure 1 and Table 3) as reported by Shippen (1982).¹ After 38 days outside the FCZ, the Aso Maru again moved inside to Hancock Seamounts for the 9-day period of the current report, before returning to Japan. I boarded the Aso Maru from a U.S. Navy tugboat at Midway on September 18. My work on board the Aso Maru was greatly facilitated by the cooperation and hospitality of the officers and crew. For interpretative assistance, I must thank Captain H. Kumamaru, Chief Engineer T. Watanabe, and Chief Officer T. Kondo.

¹Shippen, Nathaniel T. 1982. Seamount fishery, foreign vessel observer report, Aso Maru (July 17-August 10, 1982). Southwest Fish. Cent. Admin. Rep. H-82-16, 7 p. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

Table 2.--Vessel and gear specifications and personnel, Aso Maru.

Vessel:

Permit number	JA820288A
Length	90.45 m
Gross tonnage	3,608.29 short tons
Net tonnage	1,968.81 short tons
Width	16.0 m
Draft	9.80 m
Engine type	6 cylinder diesel
Fuel consumption	3-4 kl/day
Horsepower	3,900
Hull number	96090
Registration number	TOEN-701
Company/owner	Nippon Suisan Kaisha, Ltd.
Vessel type	Independent stern trawler
Year launched	1964
Port of registry	Tokyo, Japan
Home port	Tobata, Kitakyushu, Japan
Radio call sign	JMVD

Gear:

Net dimensions	See Figure 2
Door dimensions	See Figure 2
Main trawl winch	Electric 395 kW
Total wire on drum	1,900 m
Flash freezer capacity	27 MT
Processing speed	2 MT/h

Personnel (51 total ship's complement) and experience in seamount fishery

Captain - Mr. Hideo Kumamaru	4 years
Radio operator	None
Navigation officers (3)	None
Doctor	None
Engineers (4)	None
Oilers	None
Galley crew (4)	None
Deck and processing	None

The deck and factory arrangement of the Aso Maru has been described in detail in previous observer reports² as have the navigation and trawling techniques required by the small area and rough bottom of this fishing

²Evering, George C., Jr. 1979. Seamount fishery, foreign vessel observer report, Aso Maru (May 27-July 10, 1979). Southwest Fish. Cent. Admin. Rep. H-79-14, 10 p. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

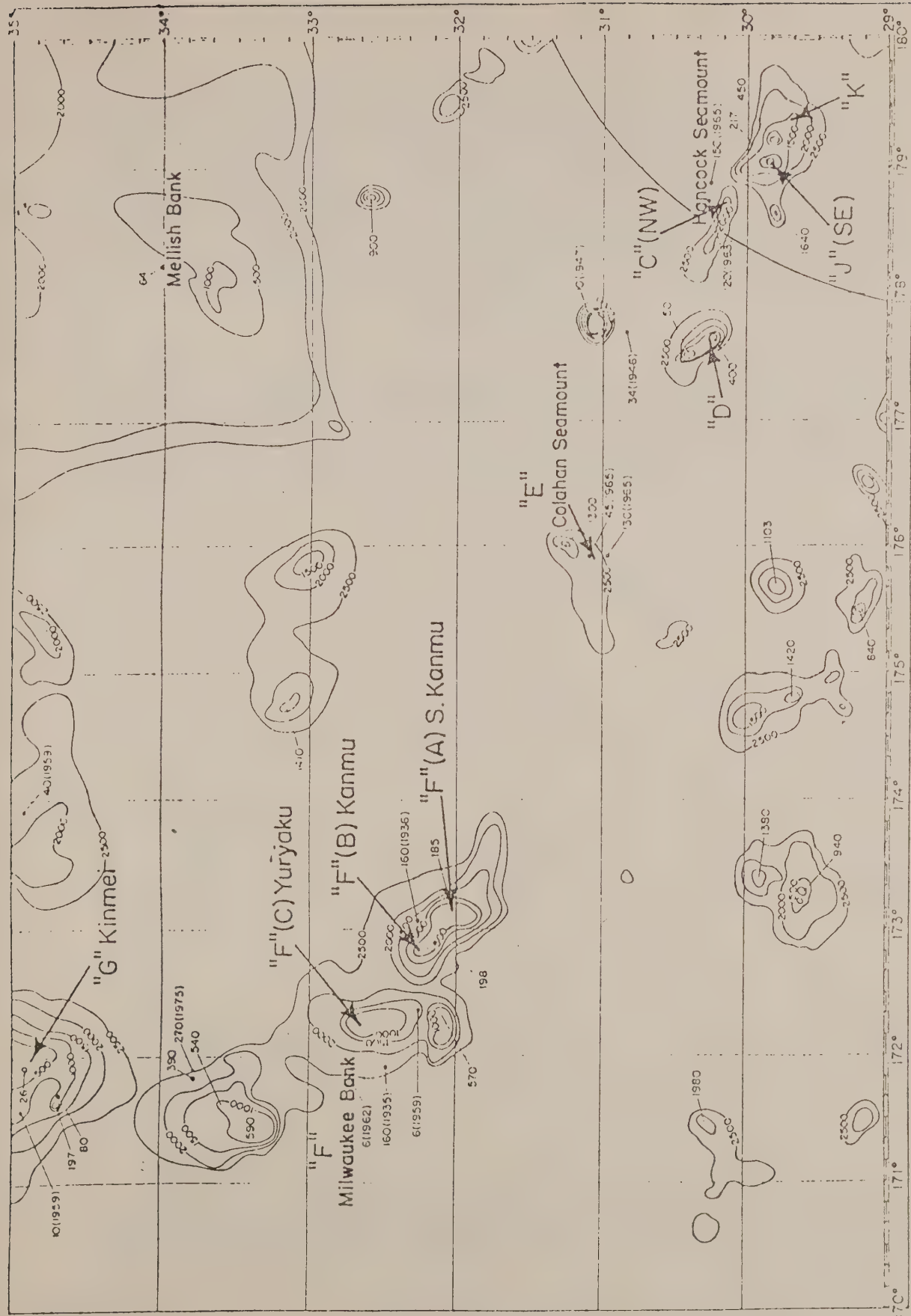


Figure 1.--Locations of seamounts and guyots northwest of the Northwestern Hawaiian Islands. Year of discovery is indicated for each guyot, and the 200-mile line is shown. Depths in fathoms.

ground. The Aso Maru trawled day and night, making repeated passes over the seamount during each haul. Although Captain Kumamaru has had several years' previous experience at Hancock Seamounts using the same gear (Figure 2), catch rates were extremely low during this fishing period. The Aso Maru caught only 2 to 4 tons per night (Tables 4-6). By comparison, the catch rates obtained by the Takachiho Maru, the first trawler to fish this season, averaged 10 to 20 tons per night (Barnett 1982³). All catch rates this year have been greatly below those of any previous season and evince the continued trend of lower availability of these fish stocks.

SAMPLING METHODS

Sampling was conducted during hauls made at night and early morning, these being the times of maximum catch. Hauls made after sunrise and before late evening were regularly the lowest in volume and generally contained no target species. Even at night, I was frequently unable to sample some hauls due to low volume. Approximate catch volumes were noted on almost every haul for comparison with vessel records.

Table 3.--Area of operation.

Emperor Seamounts	Nippon Suisan designation	Position	
		Latitude N	Longitude E
Kinmei	G Bank	35°00'	171°45'
Milwaukee group			
Yuryaku	FC Bank	32°40'	172°15'
Kanmu	FB Bank	32°15'	172°47'
South Kanmu	FA Bank	32°02'	173°06'
Colahan	E Bank	31°00'	175°55'
Unnamed	D Bank	30°26'	177°28'
<u>Fishery Conservation Zone</u>			
Northwest Hancock	C Bank	30°16'	178°42'
Southeast Hancock	J Bank	29°48'	179°04'
Southeast Hancock	K Bank	29°40'	179°20'

³Barnett, William B. 1982. Seamount trawl fishery, foreign vessel observer report, Takachiho Maru (May 3-17, 1982). Southwest Fish. Cent. Admin. Rep. H-82-12, 12 p. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812

Japanese independent
Type of Vessel: stern trawler

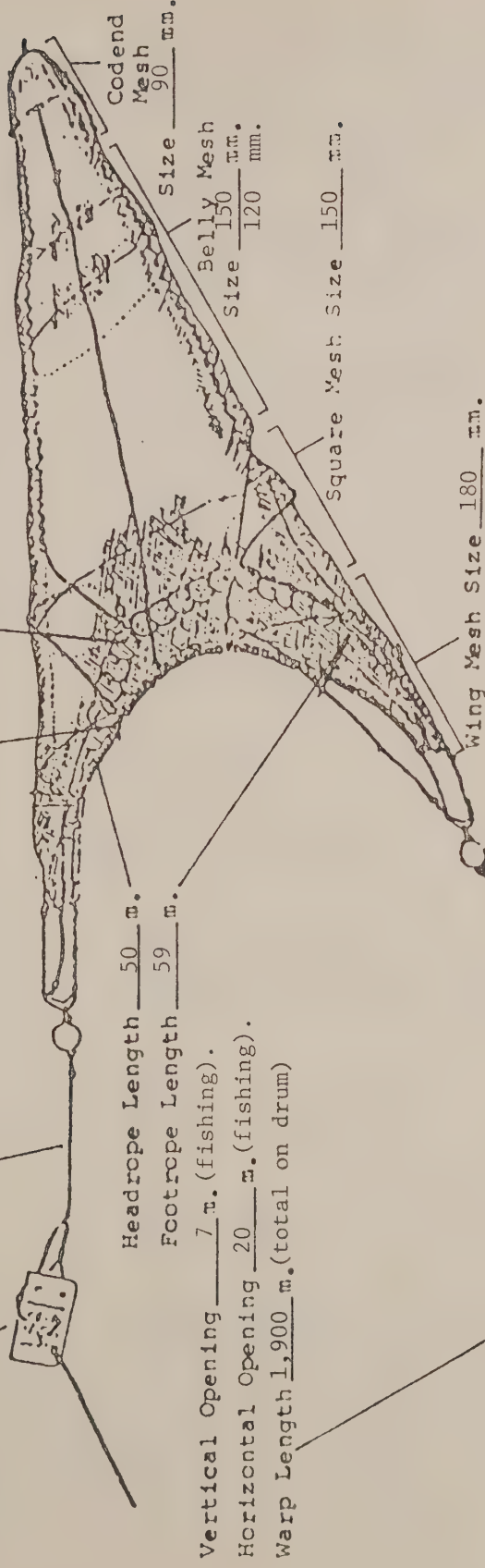
Observation Period September 18-October 6, 1982

Trawl Doors: Shape Rectangular
Type Steel, convex
Dimensions 2.2 m. x 4.4 m.
Weight 3261.5 kg.

Floats: Number 40
Size 360-440 mm
Material Cyclocac - plastic
Shape Spherical

Dandyline Length 110 m.

Bobbins: Number 104
Size 150 x 200 mm
Material Steel, rubber
Shape Cylinder, sphere



Net Recorder:

Name Furuno
Model Number ENR-50
Frequency 50 Khz

Fish Finder:

Name Kaijo Denki
Model Number W-655-CHR-562-JM
Frequency (Khz) 200/50/24
Paper Type - Wet X Dry
Speed of Advance 1 cm/min

Figure 2.--Net dimensions and characteristics, Aso Maru.

Table 4.--Summary of catch and products by species, Aso Maru,
September 18-26, 1982.

<u>Target species</u>	
Common name	Pelagic armorhead, boarfish
Japanese name	Kusakari tsubodai
Scientific name	<u>Pentaceros richardsoni</u> Smith
Federal species code ¹	200
Catch	8.3 MT
Product (4.7 MT, 225 cases)	Headed, gutted, and frozen in 21-kg cases. Heads and viscera used for fishmeal and oil.
Common name	Alfonsin
Japanese name	Kinmedai
Scientific names	<u>Beryx splendens</u> , <u>B. decadactylus</u>
Federal species code ¹	201
Catch	5.0 MT
Product (2.6 MT; round: 19 cases, dressed: 105 cases)	Dressed and frozen (large) or whole frozen (small) in 21-kg cases.

Incidental species

Federal species code: 4991; catch = 7.8 MT; frozen product = 3.8 MT
(round: 53 cases; dressed: 91 cases; fillet: 32 cases);
oil² = 1.9 MT; meal² = 1.7 MT (57 bags).

Common name	Mirror dory
Scientific name	<u>Zenopsis nebulosa</u>
Product	Filletted frozen (large only) Meal/oil
Common name	(None)
Scientific name	<u>Hyperoglyphe japonica</u>
Product	Dressed, frozen
Common name	(None)
Scientific name	<u>Ariomma lurida</u>
Product	Whole, frozen
Common name	Mackerel
Scientific name	<u>Scomber japonicus</u>
Product	Whole, frozen

¹Federal Register 43(244):59301, December 19, 1978.

²Includes heads and viscera of target species.

Table 5.--Trawl catch (kilograms) by species and area.

Species	Northwest	Southeast		All FCZ banks
	<u>Hancock Seamount</u> C Bank	<u>Hancock Seamount</u> J Bank	K Bank	
Armorhead	2,604	4,769	900	8,273
Alfonsin	890	470	3,673	5,033
Others	2,406	4,961	427	7,794
Total	5,900	10,200	5,000	21,100

Table 6.--Catch per unit effort (kilograms per minute)
by area and species.

	Northwest	Southeast		All FCZ banks
	<u>Hancock Seamount</u> C Bank	<u>Hancock Seamount</u> J Bank	K Bank	
No. of hauls	19	41	19	79
Total minutes of trawling ¹	1,340	2,425	310	4,075
Armorhead				
Total catch (kg)	2,604	4,769	900	8,273
CPUE (kg/min)	1.9	2.0	2.9	2.0
Alfonsin				
Total catch (kg)	890	470	3,673	5,033
CPUE (kg/min)	0.7	0.2	12.0	1.2
Other species				
Total catch (kg)	2,406	4,961	427	7,794
CPUE (kg/min)	1.8	2.0	1.4	1.9
All species				
Total catch (kg)	5,900	10,200	5,000	21,100
CPUE (kg/min)	4.4	4.2	16.1	5.2

¹Includes turns off the seamount.

When volumes permitted (i.e., when a basketful of fish could be sampled without holding up the factory), a random sample of the catch was shoveled into a basket and sorted by species. The various groups were each weighed in one basket of known weight on a 12-kg spring scale. When any group weighed over 12 kg (including the basket), it was subdivided and weighed in smaller lots. This method was used to estimate the species composition of the haul, although it was frequently necessary to add in the estimated weights of large fish such as sharks and walrus, Ruvettus pretiosus, which were never included in the basket samples.

The random basket sample often did not include enough fish of the target species for the length-weight-sex data form. In this case, up to 30 fish of the target species were selected at random from the conveyor to make up this portion of the sample (Tables 7 and 8). Lengths were determined on a measuring board and weights on a 3-kg handheld spring scale. Sex and body type (i.e., fat or lean) data were also recorded. No otoliths were taken. Armorhead were judged to be one of three types: lean-type fish having less fat, hollow bellies, and generally appearing thinner than the other two types of fish; well filled-out or fat fish, which were noticeably heavier than the leans, but had the same brownish coloration; and fish with the markedly different square body shape and bluish coloration which distinguishes the true fat-type armorhead. Fish in this last group were caught infrequently, but perhaps more than had been caught in other cruises during this and previous seasons.

Alfonsins occurred in distinct large and small size groups.

OBSERVATION SUMMARY

In comparing the results among vessels and seasons, the data collected to date do not allow the identification of any definitive causative factors on fluctuations in the catches. However, certain empirical observations may contribute to a better understanding of this fishery. The following observations are based on my own firsthand experience on the Kitakami Maru (1981), the Takachiho Maru (1982), and the present cruise. A primary problem in making such comparisons is the lack of data over entire seasons. The results from these cruises indicate that the catch rates will be better in the spring and worse in late summer (Table 1). Armorhead seem to diminish dramatically as the summer progresses, suggesting that seasonal behavior may play a major role in the availability of these fish. Such behavior could be related to feeding or reproduction, and could be influenced by temperature, currents, day length, or other physical, chemical, and biological factors. The minor differences in vessel efficiency would probably not cause the observed drop in catch rates, although such differences cannot be completely discounted. One such difference between vessels is that the Takachiho Maru fished exclusively at night. It might be suggested that the respite from trawling during the day allowed the fish time to regroup and settle before each night's fishing, whereas continual trawling by the Aso Maru may have disturbed the bottom and caused the fish to remain dispersed, resulting in lower catches.

Table 7.--Summary of biological observations on 410 armorheads.

Location	Average fork length (mm)	Average weight (kg)	<u>Sex ratio</u> M/F %	Body type
				<u>ratio</u> ¹ Fat/lean %
Northwest Hancock C Bank	301	0.46	63/37	33/67
Southwest Hancock J Bank	304	0.46	10/90	34/66
K Bank	302	0.47	63/37	42/58
All FCZ banks	302	0.46	44/56	36/64
Range	267-334	0.33-064		

¹See discussion of body types under Sampling Methods.

Table 8.--Summary of biological observations on 127 alfonsins.

Location	Average fork length (mm)		Average weight (kg)		Sex ratio ¹
	Large	Small	Large	Small	M/F
					%
Northwest Hancock					
C Bank	306	180	0.66	0.14	46/54
Southwest Hancock					
J Bank	304	194	0.51	0.18	
K Bank	359	0	1.02	0	80/20
Range	159-427		0.10-1.60		

¹Small fish not measured.

A characteristic of this fishery is that for any given date, the best catches are made before sunrise, generally between 0300 and 0500. This is a period when the fish are most concentrated at fishing depths, and in which markedly fewer incidental species are caught. The size and body-type distributions seem to be similar in day or night catches, but the armorhead taken during the day seemed to have been feeding primarily in the morning. The greatest percentage of full stomachs occurred about 1000.

Food of armorhead seems to be an assortment of benthic caridean shrimps and mesopelagic (salps) organisms. Alfonsins were noted to be feeding upon both forms as well, with a slightly greater incidence of benthic shrimp and fish. Also a large amount of fine silt were generally present in the gut of alfonsins.

To review the season at Hancock Seamounts, catch per unit effort (CPUE) of all species at all seamounts dropped from 36 to 5 kg/min between May and September. The CPUE for armorhead dropped from 33 to 2 kg/min for all banks. The CPUE for alfonsins was erratic, showing no obvious trends. Although some catch rates at K Bank have been exceptionally high, the small size of this bank, short trawling times, and low effort make all conclusions speculative.

Among the banks of this group, J Bank produced slightly more fish per minute early in the season, but catch rates were uniform by the season's end.

I observed no catch of corals of any type, although the vessel carried pieces of black and bamboo coral trawled up outside the FCZ.

ITINERARY (G.m.t. dates)

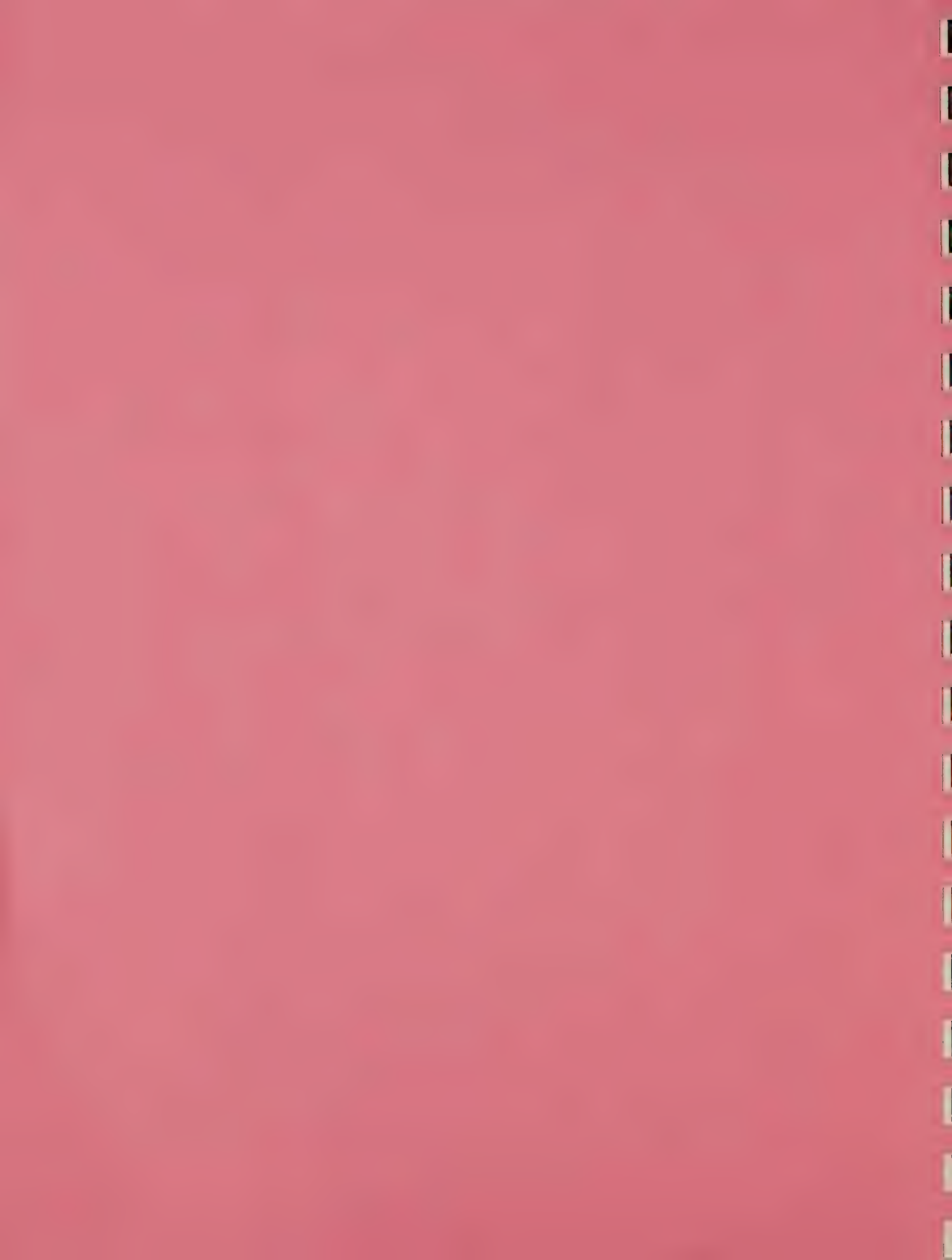
September	17	-	Honolulu (Hickam AFB) to Midway
	18	-	Embarked <u>Aso Maru</u> , began sampling
	26	-	Ceased fishing, departed FCZ
October	5	-	Arrived Tobata, Japan
	15	-	Arrived Honolulu

RECORDS

The following records were kept:

- Scientists log
- Daily trawl haul form
- Length/weight/sex log
- Species composition from basket samples
- Time and attendance form
- Radio report files
- Photographs

OBSERVER: William B. Barnett





U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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PROCEDURES TO BE FOLLOWED IN PREPARING WEEKLY AND MONTHLY REPORTS
ON SKIPJACK TUNA LANDINGS IN HAWAII

By

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OCTOBER 1982

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INTRODUCTION

The National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory prepares weekly and monthly estimates of skipjack tuna landings as part of its routine monitoring of fisheries in Hawaii. The purpose of this report is to document the procedures used in making these estimates.

AN OVERVIEW

The weekly and monthly reports contain information on the skipjack tuna landings made at the cannery (Hawaiian Tuna Packers, Bumble Bee Seafoods, Inc.) and from these, estimates of the statewide skipjack tuna landings. The cannery landings provide the raw data for making such statewide estimates.

Statewide estimates are based on the relationship between the amount of catch reported to the Hawaii Division of Aquatic Resources (HDAR) (statewide landings) and the landings made at the cannery by the Tuna Boat Owners Cooperative (TBOC) vessels. This relationship is computed using data from 1964 through the latest year for which complete data are available, in this case 1979. The resulting relationship is

$$L_T = 1.4121 L_C + 133,880 D. \quad \text{Equation 1}$$

This regression procedure is described in Appendix I.

The remainder of this report will consist of the computational procedures used in preparing the weekly and monthly reports as well as various tables, worksheets, and forms.

TABLES, WORKSHEETS, AND FORMS

Appendix II contains two tables, two worksheets, and four forms. The tables are used to make comparisons with past landings, the worksheets are used to obtain information on the current year's landings, and the forms are used to collect the raw data and to present summaries of current weekly and monthly landings and estimates.

Tables 1 and 2 contain landings recorded in metric tons (MT). Worksheet 1 contains landings recorded in both pounds and metric tons, while Worksheet 2 contains landings recorded in pounds except when noted as metric tons. Landings are recorded in pounds on Form 1 and in metric tons on Forms 2, 3, and 4.

Generally, the terminology used on these tables, worksheets, and forms is easily understood or is explained elsewhere in this report. However, two terms require definitions. On Worksheet 2, "days fishing" simply refers to

the number of vessels fishing during a particular week. Similarly, on Form 2, "trips" refers to the number of vessels fishing during the week with "effective" indicating trips where skipjack tuna were landed and "zero catch" indicating trips where no skipjack tuna were landed.

DATA COLLECTION

Data on cannery landings of skipjack tuna are collected each Monday and recorded on Form 1 (Aku boat landings at Hawaiian Tuna Packers). The reporting week is 7 days from Monday through Sunday.

All sales to the cannery are recorded. This may include both TBOC vessels and United Fishing Agency (UFA) vessels. The "control number," which identifies this data set in the Honolulu Laboratory's data management system, is 36. (It should be noted that the control numbers are being replaced by a new index code being set up by Data Management and Technical Services.) The "boat" codes currently used are presented below along with, in parentheses, the affiliation of the boats:

34	<u>Anela</u>	(UFA)
51	<u>Angel</u>	(UFA)
52	<u>Bluefin</u>	(TBOC)
57	<u>Corsair</u>	(TBOC)
58	<u>Kula Kai</u>	(TBOC)
62	<u>Kilohana</u>	(UFA)
64	<u>Marlin</u>	(TBOC)
66	<u>Neptune</u>	(TBOC)
70	<u>Sea Queen</u>	(TBOC)
72	<u>Lehua</u>	(UFA)
74	<u>Tradewind</u>	(TBOC)
75	<u>Yellowfin</u>	(TBOC)

Although they are not used in preparing weekly and monthly reports, UFA catches which are not sold to the cannery are recorded on a separate Form 1. These catches are found at the bottom of the cannery data sheet (obtained from cannery personnel) and usually catch by size is not provided.

PREPARING THE WEEKLY SKIPJACK TUNA LANDINGS REPORT

Form 2 (Weekly skipjack tuna landings report) consists of two sections. The first deals with actual cannery landings of skipjack tuna and the second with our estimates of statewide landings.

Section I includes all landings made directly at the tuna cannery by TBOC and UFA boats as well as UFA landings returned to the cannery from the market (UFA auction). Landings from the neighbor islands and UFA market sales are excluded. The "landings per trip" and "size composition" responses use a different set of landings, namely the TBOC vessel landings exclusively. This procedure is followed because UFA boats do not always land their entire catch at the cannery.

Section II presents estimates obtained by using only cannery landings by TBOC boats in Equation 1. The neighbor island landings, UFA returns, and UFA market sales are not considered cannery landings in this estimation procedure.

Procedures for Completing Section I

The procedures followed in completing this section are described below. Except as noted in steps 4, 5, and 6, UFA returns and TBOC landings should be used.

1. From Form 1, add the weights of each size group to check the boat total.
2. Using Form 1, obtain the total landings for the week by adding all the boat totals for the week and then convert this sum to metric tons by multiplying by 0.0004536. Record on Form 2, accurate to one decimal place.
3. Using Form 1, determine the number of effective trips and zero-catch trips. Add these to obtain the total number of trips. Record these on Form 2.
4. Calculate the total landings in pounds for TBOC vessels only. (Use Form 1.) Divide this by the number of total trips by TBOC vessels. Convert this to metric tons. Record this on Form 2, accurate to one decimal place.
5. Using Form 1, calculate for the entire week the total weight landed by TBOC vessels for each size group (large, medium, small, and extra-small). Do not differentiate extra-small from extra-extra-small. There is no small-medium size group presently. Make weekly entries on Worksheet 2. Convert landings to metric tons and record on Form 2, accurate to one decimal place.
6. For size-composition percentages, divide the total weight in pounds of each size group by the total landings for the week (in pounds) to obtain the percentages for each size group. (Use only TBOC vessel landings.) As a check, all the percentages should add up to 100%. Record on Form 2 as whole percentages.
7. For comments, note all dates when no fishing effort was expended and other pertinent information concerning weather conditions, bait supply, neighbor island landings, and changes in calculation procedures.

Procedures for Completing Section II

The procedures followed in completing this section are described below. Only the TBOC landings should be used in the statewide estimations.

1. To estimate total State landings for the week, take the total landings in pounds by TBOC vessels (calculated in step 4 above) and multiply this by 1.4121 (see Equation 1). If the fishing week is contained fully in the period January through May or October through December, simply convert the above product to metric tons and record on Form 2. For example, cannery landings of 10,000 lb $\times$ 1.4121 = 14,121 lb, and then 14,121 lb $\times$ 0.0004536 MT/lb = 6.4 MT. However, if some of the days fall in the period June through September, an adjustment must be added to the product calculated above. The general form of this adjustment is:

$$\left(\frac{\text{Number of fishing days falling in month}}{\text{Total days in month}} \right) \times 133,880.$$

For example, a fishing week of September 28, 1981 through October 4, 1981 would result in an addition of $(3/30) \times (133,880) = 13,388$ prior to the conversion to metric tons (13,388 lb + 14,121 lb = 27,509 lb; then 27,509 lb $\times$ 0.0004536 MT/lb = 12.5 MT).

Similarly, a fishing week of June 29, 1981 through July 5, 1981 would result in an addition of $(2/30) \times (133,880) + (5/31) \times (133,880) = 30,518.9$ where 2 is the number of fishing days in June, 5 is the number of fishing days in July, 30 is the number of days in June, and 31 is the number of days in July. Simply add this adjustment to the $(1.4121 \times \text{TBOC landings})$ figure and convert to metric tons. Record the statewide landings estimate on Form 2, accurate to one decimal place.

2. Complete the weekly entries on Worksheet 1. The last column will provide the figure for cumulative landings to date. Record on Form 2, accurate to one decimal place.
3. The remainder of the weekly report figures can be obtained by comparing this cumulative landings figure (step 2) with the appropriate weekly figures in Tables 1 and 2. Record on Form 2, accurate to one decimal place. Be sure to fill in the dates used for the long-term average calculation and be sure to circle the word "above" or "below."

PREPARING THE MONTHLY SKIPJACK TUNA LANDINGS REPORT

Prepare the monthly report 5 working days before the end of the month. Section I uses TBOC vessel landings only. Section II estimates are obtained from weekly estimates which are based on TBOC vessel landings only.

Procedures for Completing Section I

1. From Form 1, find the range of vessel landings for TBOC vessels for the current month (including zero catches). Using only the TBOC vessel landings for the month, calculate the landings per trip by dividing the sum of all TBOC vessel total landings by the total trips made by those vessels during the month. Convert the range and landings per trip figures to metric tons and record on Form 3, accurate to one decimal place. (Note: Worksheet 2 may be helpful for this step. Use as much of the monthly data as is available. The entire monthly data will not be available.)
2. From Form 2, determine neighbor island landings for this month. Convert these to metric tons if necessary and record on Form 3, accurate to one decimal place.
3. For the size composition for the month, using Worksheet 2, calculate the total weight in pounds of each size group and divide each of these totals by the total landings for the month (in pounds) to obtain the percentages of the total landings contributed by each size group. As a check, the percentages should add up to 100%. Record on Form 3 as whole percentages.

Procedures for Completing Section II

1. To obtain estimated skipjack tuna landings for the month, use Worksheet 2. Using the most recent value in the "cumulative total" column, calculate the estimated statewide landings for the portion of the month for which you have landings data. First, multiply this value by 1.4121. Call this value A. If the month is June, July, August, or September, multiply 133,880 by the number of days that have passed in the month and divide by the number of days in the month. Call this value B. For any other month, B equals zero. Add values A and B to obtain the estimated statewide landings for this period. Multiply this value by the number of days in the month and divide by the number of days in the period. Convert this to metric tons and record on Form 3, accurate to one decimal place.
2. Compare the estimated monthly landings in metric tons (step 1) with appropriate estimates of monthly landings from Tables 1 and 2. Perform the necessary subtractions and record on Form 3, accurate to one decimal place. Be sure to circle the word "above" or "below."
3. Add the monthly landings estimate (step 1) to the cumulative monthly landings estimate (CMLE) for prior month in metric tons (Worksheet 2). Record this on Form 3, accurate to one decimal place.

4. Compare the cumulative monthly statewide landings estimate (step 3) with appropriate cumulative landings figures from Tables 1 and 2. Perform the necessary subtractions and record on Form 3, accurate to one decimal place. Be sure to circle the word "above" or "below."
5. Using Worksheet 2 and the results of step 3, plot the year's estimated statewide cumulative landings on the graphs found on Forms 3 and 4.
6. This step is to be done after all data for the month are obtained, not 5 working days prior to the end of the month. Enter the remaining data needed to determine the monthly landings estimate on Worksheet 2.

UPDATING

The skipjack tuna landings report procedure will require periodic updating as the result of the availability of new data or change of calendar year. The following portions of the procedure require such updating:

1. Table 1.--Mean weekly State skipjack tuna landings (1964-79 mean).
2. Table 2.--1981 weekly State skipjack tuna landings.
3. Equation 1. The regression of the HDAR reported catch on TBOC cannery landings.

Table 1 should be updated as additional yearly data are made available by the HDAR. Computer Program 1 (see Appendix III) provides the 12 monthly long-term average catch values (AMFCATMT) needed for the revision of Table 1. These values should be put in the "19__-__ monthly mean landings" column. The remainder of the revisions to Table 1 are based on these new values.

Table 2 should be updated near the end of the calendar year so that landings comparisons may continue with the start of a new calendar year. Use Worksheet 2 to update Table 2. The new values for the "landings" column will be the "monthly landings estimates" (MLE) values in metric tons found in the last column of Worksheet 2. The remainder of the revisions to Table 2 are based on these new values.

The updating of the regression is done at the same time Table 1 is updated. Indeed, Computer Program 1 which provides the new values for Table 1, also creates a time share option (TSO) data file which may be used in the revision of the regression. This data set will contain information identifying the year and month, dummy variables representing the month (all zeros represent December), monthly TBOC vessel landings in pounds, monthly catch in pounds as reported to the HDAR, average TBOC vessel landings in pounds over all years for that month, and average catch in pounds over all

years for that month as reported to the HDAR. The dummy variables allow for the inclusion of a seasonal effect on the relationship between the independent and dependent variable. The inclusion of the "average monthly" landings and catch values allows for a monthly long-term adjustment. The regression used at this time makes use of the dummy variables but does not include any long-term monthly adjustment.

The regression analysis of this data set may use any existing regression analysis package. However, SHAZAM, a program package for econometric methods, was used in establishing the current regression relationship.

Computer Program 2, the program used to determine the appropriate regression equation, can be found in Appendix III. The information needed to access the data set created by Computer Program 1 and used in Computer Program 2 is represented in Appendix IV. Again, it should be stressed that it is not necessary to use every available variable in the TSO data set. Likewise, it is not necessary to use the same regression analysis as that used in Computer Program 2. Computer Program 2 is only an example of the procedure used to obtain the existing regression equation.

APPENDIX I

The regression used in making the estimates of statewide skipjack tuna landings is:

$$L_T = 1.4121 L_C + 133,880 D$$

where:

L_T is the estimate for monthly statewide skipjack tuna landings in pounds,

L_C is the monthly skipjack tuna landings by TBOC vessels at the cannery in pounds, and

D is a dummy variable with value 1 in June through September and value 0 for all other months.

This relationship was derived by regressing the amount of catch reported to the HDAR on the landings made at the tuna cannery by TBOC vessels. The data used in this document covered a period from 1964 through 1979. Regressions were tried with and without intercepts and with various monthly and seasonal dummy variables. The above regression was chosen as the best. The t-value associated with L_C was 63.731 (d.f. = 190) and the t-value associated with the seasonal dummy variable, D , was 5.4475 (d.f. = 190). The regression accounted for nearly 96% of the variability in L_T .

Appendix II Table 2.--The 1981 weekly State skipjack tuna landings.

MONTH	LANDINGS	NUMBER OF DAYS IN MONTH	DAILY LANDINGS (DL) *	WEEKLY LANDINGS (WL) **		MONTH	WK	CUM. WEEKLY LANDINGS	MONTH	WK	CUM. WEEKLY LANDINGS
JAN	37.7	31	1.22	8.5		JAN	1	8.5		27	1141.0
FEB	37.1	28	1.32	9.3			2	17.0		28	1250.1
MAR	98.1	31	3.16	22.2			3	25.5		29	1359.2
APR	170.2	30	5.67	39.7			4	37.7		30	1405.9
MAY	212.1	31	6.84	47.9		FEB	5	47.0	AUG	31	1441.0
JUN	367.7	30	12.26	85.8			6	55.2		32	1556.0
JUL	483.0	31	15.58	109.1			7	65.5		33	1631.1
AUG	332.4	31	10.72	75.1			8	74.8		34	1738.3
SEP	203.0	30	6.77	47.4		MAR	9	97.0	SEP	35	1785.7
OCT	90.1	31	2.91	20.3			10	119.1		36	1833.0
NOV	62.0	30	2.07	14.5			11	141.3		37	1880.4
DEC	100.8	31	3.25	22.8			12	172.9		38	1927.8
						APR	13	212.6		39	1941.3
							14	252.3	OCT	40	1961.6
							15	292.0		41	1982.0
							16	331.8		42	2002.3
							17	343.1		43	2031.4
						MAY	18	391.0	NOV	44	2045.9
							19	438.9		45	2060.3
							20	486.8		46	2074.2
							21	555.2		47	2093.4
						JUN	22	641.0	DEC	48	2116.2
							23	726.8		49	2138.9
							24	812.6		50	2161.7
							25	922.9		51	2184.4
						JUL	26	1032.0		52	2194.2

$$*MDL = \frac{\text{Monthly landings}}{\text{Number of days in month}}.$$
$$**WL = DL \times 7.$$

Appendix II Worksheet 1.--The 1982 estimated statewide
skipjack tuna landings by week.*

TBOC BOATS		POUNDS		METRIC TONS		
WEEK	POUNDS	METRIC TONS	ESTIMATED TOTAL STATE LANDINGS	CUM. EST. TOTAL STATE LANDINGS	EST. TOTAL STATE LANDINGS	CUM. EST. TOTAL STATE LANDINGS
1	31636	14.4	44673	44673	20.3	20.3
2	22557	10.2	21853	76526	14.4	34.7
3	34290	15.6	48421	124947	22.0	56.7
4	27853	12.6	32331	164278	17.8	74.5
5	8658	3.9	12226	176504	5.5	80.0
6	13447	6.1	18980	195493	8.6	88.7
7	605	0.3	854	196347	0.4	89.1
8	19515	8.9	22357	223904	12.5	101.6
9	14234	6.5	20100	244004	9.1	110.7
10	33774	15.3	42692	291696	21.6	132.3
11	9888	4.5	13723	305659	6.3	138.6
12	12573	5.7	17224	323413	8.1	146.7
13	14669	6.7	20214	344127	9.4	156.1
14	21547	9.8	30427	374554	13.8	169.9
15	14662	6.7	20704	395258	9.4	179.3
16	37656	18.0	35907	451256	23.4	204.7
17	30755	14.0	40120	494685	19.7	224.4
18	35322	16.0	43878	544563	22.6	247.0
19	55782	25.3	78770	623333	35.7	282.7
20	45404	20.6	64115	687448	29.1	311.8
21	53827	24.4	70000	765457	34.5	346.3
22	43799	19.9	61840	825306	28.1	374.4
23	134027	60.8	216036	1041342	98.0	472.4
24	113333	51.4	171276	1252618	86.8	559.2
25	126025	57.2	207190	1441817	94.9	654.0
26	129132	58.6	213586	1655403	96.9	750.9
27	90473	41.0	158420	1813823	71.9	822.8
28	92037	41.7	160196	1974019	72.7	895.4
29	108599	49.3	183584	2157603	83.3	978.7
30	116311	52.8	194474	2352077	88.2	1066.9
31	144326	65.5	234034	2586111	106.2	1173.1
32	88721	40.2	155514	2741625	70.5	1243.6
33	20245	9.2	58819	2800444	26.7	1270.3
34	93665	42.5	162495	2962939	73.7	1344.0
35	45605	20.7	94630	3057569	42.9	1386.9
36	49014	22.2	100163	3157732	45.4	1432.3
37	67735	31.3	128582	3286314	58.3	1490.7
38	37490	17.0	86508	3372822	39.2	1530.0
39	32591	14.8	77260	3450082	35.0	1565.0
40						
41						
42						
43						
44						

*Use TBOC vessel landings only.

Appendix II. Worksheet 1.--Continued.

[illegible]

Appendix II Worksheet 2.--The 1982 worksheet to obtain monthly catch/effort, size composition, and landings estimates information.*

MONTH	WEEK	DATES	DAYS FISHING	LARGE	MEDIUM	SMALL	EXTRA SMALL	TOTAL	CUM. TOTAL
Jan	1	1-3	0	0	0	0	0	0	0
	2	4-10	8	2630	8741	10587	599	22557	22557
	3	11-17	22	3523	23712	7196	859	34290	56847
	4	18-24	12	5387	16748	4724	994	27853	84700
	5	25-31	9	75	3492	4419	672	8658	93358
			51	10615	52693	26926	3124	93358	
Monthly Landings Estimate (MLE) =				1.4121(93358) + 0(133880) =				131831.66	
								=	59.8 MT
Cumulative Monthly Landings Estimate (CMLE) =									131831.66
								=	59.8 MT
Feb	6	1-7	16	4784	3614	3877	1172	13447	13447
	7	8-14	3	0	110	495	0	605	14052
	8	15-21	15	138	5878	9303	4196	19515	33567
	9	22-28	13	3472	1760	1551	7451	14234	47801
			47	8394	11362	15226	12819	47801	
MLE =				1.4121(47801) + 0(133880) =				67500.66	
								=	30.6 MT
								CMLE	199331.66
								=	90.4 MT
Mar	10	1-7	19	2691	9594	11367	10122	33774	33774
	11	8-14	11	49	1594	2023	6222	9888	43662
	12	15-21	18	0	3972	3062	5539	12573	56235
	13	22-28	10	151	2753	5317	1448	14669	70904
	14	29-31	11	127	6024	3194	1002	10347	81251
			69	3018	28937	24963	24333	81251	
MLE =				1.4121(81251) + 0(133880) =				114735.66	
								=	52.0 MT
								CMLE	314066.66
								=	142.5 MT
Apr	14	1-4	10	112	5162	4316	1610	11200	11200
	15	5-11	23	430	2254	1826	10552	14662	25862

*Use TBOC vessel landings only.

Appendix II Worksheet 2.--Continued.

MONTH	WEEK	DATES	DAYS FISHING	LARGE	MEDIUM	SMALL	EXTRA SMALL	TOTAL	CUM. TOTAL
Apr	16	12-18	22	1120	21157	10379	7000	39656	65318
	17	19-25	20	7410	12917	5333	9095	30755	96223
	18	26-30	17	2340	5409	5518	10351	23518	119791
			92	7412	46897	26972	38508	119291	
				MLE = 1.4121(119291) + 0(133880) =					169157.46
									76.7 MT
							CME	=	483223.04
								=	219.2 MT
May	18	1-2	5	913	2997	4857	3037	11804	11804
	19	3-9	25	6043	19604	21730	8405	55782	67586
	20	10-16	22	8960	11941	13825	10678	45404	112990
	21	17-23	25	17313	6120	18035	12359	53827	166817
	22	24-30	29	10333	6370	14191	12905	43799	210616
	23	31	6	4464	316	1801	3948	10529	221145
			112	48026	47348	74439	57332	221145	
				MLE = 1.4121(221145) + 0(133880) =					312279.26
									141.6 MT
							CME	=	795502.44
								=	360.8 MT
Jun	23	1-6	24	101570	727	12999	8202	123498	123498
	24	7-13	30	95253	9671	6391	2018	113333	236831
	25	14-20	23	110442	790	4899	9894	126025	362856
	26	21-27	27	96012	6843	22137	4140	129132	491988
	27	28-30	13	13948	11746	35513	11823	72430	564418
			117	417225	29177	81939	36077	564418	
				MLE = 1.4121(564418) + 1(133880) =					930895.44
									422.3 MT
							CME	=	1726377.64
								=	783.1 MT
Jul	27	1-4	9	3009	3547	9117	2370	18043	18043
	28	5-11	21	51594	5872	21481	13087	92037	110080

Appendix II Worksheet 2.--Continued.

MONTH	WEEK	DATES	DAYS FISHING	LARGE	MEDIUM	SMALL	EXTRA SMALL	TOTAL	CUM. TOTAL
Jul	29	12-18	25	58432	13566	26564	10037	108599	218679
	30	19-25	25	75896	11613	18562	10240	116311	334990
	31	26-31	20	112090	4700	8082	13791	138663	473653
			100	301021	39298	83809	49525	473653	
				MLE = $1.4121(473653) + 1(133880)$				=	802725 $\frac{1}{2}$
								=	364.1 MT
							CMLE	=	2529122 $\frac{1}{2}$
								=	1147.2 MT
Aug	31	1	1	0	2528	2786	349	5663	5663
	32	2-8	22	65001	2345	10974	10351	88721	94384
	33	9-15	9	230	3396	5142	11477	20245	114629
	34	16-22	26	57486	6144	15933	14102	92665	208294
	35	23-29	16	37137	0	1952	6516	45605	253899
	36	30-31	4	2742	111	1383	1870	6106	260005
			78	162598	14574	38170	44665	260005	
				MLE = $1.4121(260005) + 1(133880)$				=	501033 $\frac{1}{2}$
								=	227.3 MT
							CMLE	=	3030155 $\frac{1}{2}$
								=	1374.5 MT
Sep	36	1-5	21	18082	2711	12523	9592	42908	42908
	37	6-12	23	19145	17383	25071	7311	68935	111843
	38	13-19	23	22066	2584	6487	6353	37490	149333
	39	20-26	14	2925	5883	10066	13717	32591	181924
	40	27-30							
				MLE = $1.4121() + 1(133880)$				=	$\frac{1}{2}$
								=	MT
							CMLE	=	$\frac{1}{2}$
								=	MT
Oct	40	1-3							
	41	4-10							

Appendix II Worksheet 2.--Continued.

MONTH	WEEK	DATES	DAYS FISHING	LARGE	MEDIUM	SMALL	EXTRA SMALL	TOTAL	CUM. TOTAL
Oct	42	11-17							
	43	18-24							
	44	25-31							
				MLE = 1.4121 () + 0 (133880) =					46
									MT
								CMLE	46
									MT
Nov	45	1-7							
	46	8-14							
	47	15-21							
	48	22-28							
	49	29-30							
				MLE = 1.4121 () + 0 (133880) =					47
									MT
								CMLE	47
									MT
Dec	49	1-5							
	50	6-12							
	51	13-19							
	52	20-26							
	1(83)	27-31							
				MLE = 1.4121 () + 0 (133880) =					48
									MT
								CMLE	48
									MT

AKU BOAT LANDINGS AT HAWAIIAN TUNA PACKERS

[illegible]

* RATIO IF FISH WERE MEASURED

School size: _____ Put the number of schools in as given by boat. If the number is unknown, use 99.
(Columns 76-77)

Vessel code:
(Columns 4-5)

50	Amberjack
51	Angel
52	Bluefin
53	Bonito
54	Broadbill
55	Buccaneer
56	Constance
57	Corsair
58	Darling Doll
59	Dolphin
60	Electa
61	Holokahana
62	Kilohana
63	Makanani
64	Marlin
65	Momi
66	Neptune
67	Olympic
68	Orlon
69	Sailfish
70	Sea Queen
71	Skipjack
72	Sooty Tern
73	Sunfish
74	Tradewind
75	Yellowfin

Ratio code
(Columns 71-72)

01	All
02	1/2
03	1/3
04	1/4
05	1/5
06	1/10
07	1/15
08	1/20
09	1/25
10	50
11	Other

Activity code:
(Columns 79-80)

01 Length frequencies
02 Length frequencies, weights, stomachs, and gonads
03 Length frequencies and blood
04 Blood

- 05 Boat landed before working hours
- 06 Boat landed after working hours
- 07 Boat landed on a weekend or holiday
- 08 Boat landed fish at another port
- 09 Boat with fish from an outside island
- 10 Missed boat because of work with another boat
- 11 Water fish
- 12 Other reasons; reason listed on original data sheet
- 13 Split catch; fish wholesalers take part of catch before work can be done
- 14 United Fishing Agency; no work possible; exact weight of catch
- 15 United Fishing Agency; no work possible; estimate of total catch
- 16 United Fishing Agency; no work possible; Bumble Bee Seafoods, Inc. weight (cannery fish only)
- 17 Catch too small to get data from
- 18 Fish wrong size to bleed

[illegible]

Appendix II Form 2.--Weekly skipjack tuna report.

Date _____

I. Cannery Landings

Total Landings _____ Metric Tons

Trips: Effective _____

Zero-catch _____

Total _____

Landings Per Trip _____ Metric Tons *

Size Composition: *

	<u>Metric Tons</u>	<u>Percent</u>
Large	_____	_____
Medium	_____	_____
Small	_____	_____
Extra Small	_____	_____

Comments: _____

II. Statewide Estimations **

The estimated total State landings last week was _____ metric tons (MT),

bringing the cumulative landings to date to _____ MT. This is _____ MT

ABOVE BELOW the long-term average (19__ - __) for the same period and _____ MT

ABOVE BELOW last year's landings.

* Based solely on TBOC vessel trips and landings. UFA returns to cannery are excluded.
 ** Current-year estimate and last-year comparison figure based on regression of Hawaii Division of Aquatic Resources reported catch on TBOC cannery landings. Long-term comparison figure based solely on Aquatic Resources reported catch.

Appendix II Form 3.--Monthly skipjack tuna landings report.

MONTH _____ YEAR _____

I. Cannery Landings

Landings of Oahu-based vessels ranged from _____ to _____ metric tons (MT);
their landings per trip was _____ MT. *

Landings shipped to the tuna cannery from neighboring islands were:

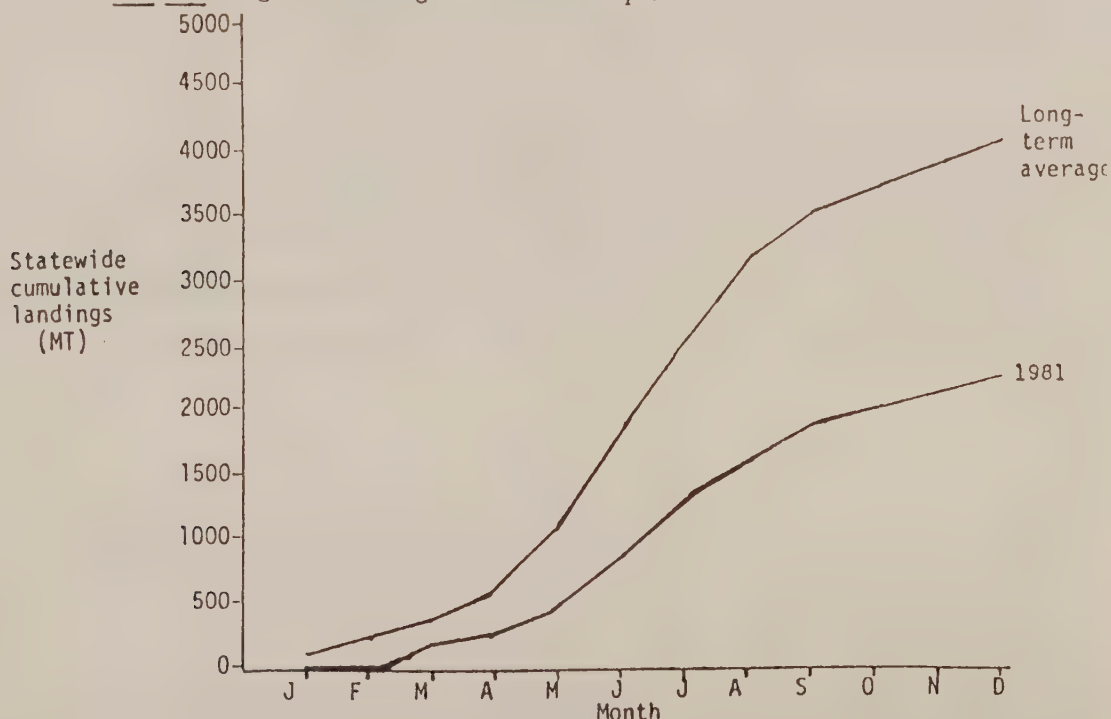
Hawaii _____ Maui _____ Unidentified _____

Size Composition (Percent) **

Large (6.8 kg) _____ Medium (3.6-6.8 kg) _____ Small (1.8-3.6 kg) _____ Extra small (1.8 kg) _____

II. Statewide Estimations **

The Hawaii landings of skipjack tuna during _____ were estimated at _____ MT,
which is _____ MT ABOVE BELOW the landings for the same period last year and _____ MT
ABOVE BELOW the 19____-____ long term average for the same period. The cumulative
landings from January through _____ were estimated at _____ MT, which is _____ MT
ABOVE BELOW last year's cumulative landings for the same period and _____ MT ABOVE
BELOW the 19____-____ long term average for the same period.



* Based solely on TBOC vessel trips and landings. UFA returns to cannery are excluded.

** Current-year estimate and last-year comparison figure based on regression of Hawaii Division of Aquatic Resources reported catch on TBOC cannery landings. Long-term comparison figure based solely on Aquatic Resources reported catch.

Appendix II Form 4

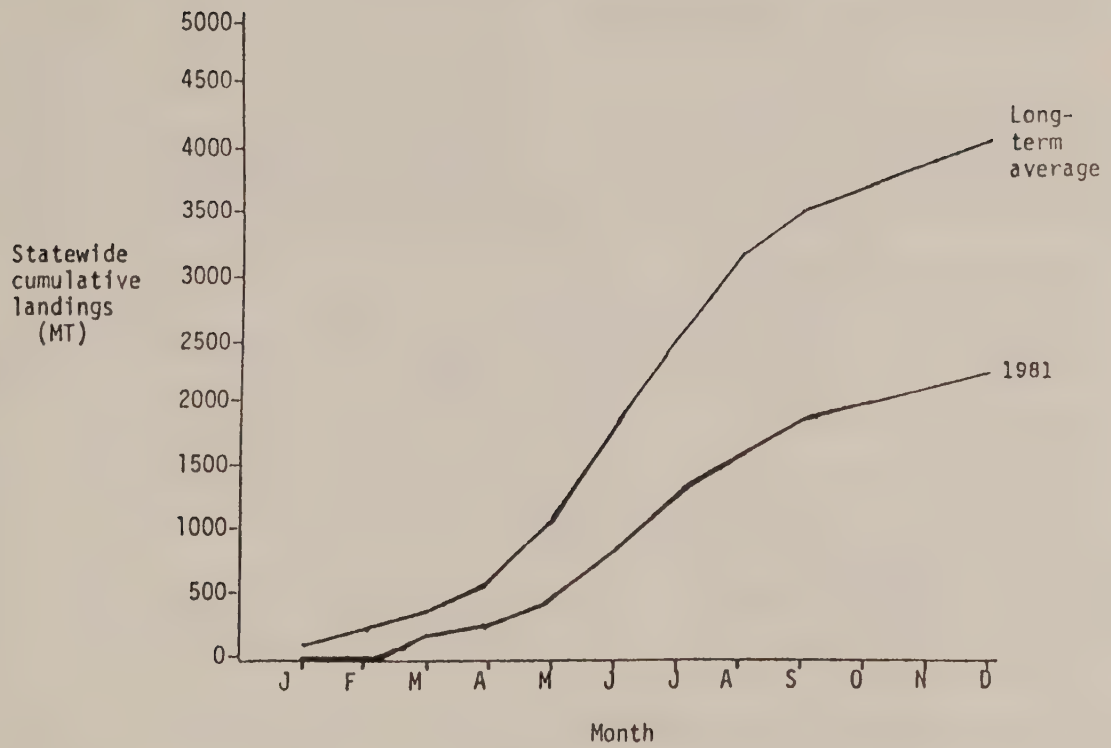


Figure 1.--Cumulative landings in the Hawaiian skipjack tuna fishery.

Appendix III

Computer Program 1

```

//HTPFG JOB (1078,9M,9KI,187F), 'GARY KAMER', REGION=700K
// EXEC SETUP
//SYSIN DD *
V=X21811,T=X21811,SZ=H,NORING
V=X21861,T=X21861,SZ=H,NORING
/*
// EXEC SAS, SORT=30, WORK=30
//SAVE DD DSN=T010780.HTPFG, UNIT=TSSDA1, DISP=SHR
*THIS COMPUTER PROGRAM WAS WRITTEN BY GARY KAMER, STATISTICIAN FOR
*THE NATIONAL MARINE FISHERIES SERVICE, SOUTHWEST FISHERIES CENTER,
*HONOLULU LABORATORY. THIS PARTICULAR FORM OF THIS PROGRAM WAS
*COMPLETED ON 10/16/82 AND IS USED FOR UPDATING THE DATA USED IN THE
*PREPARATION OF THE WEEKLY AND MONTHLY SKIPJACK TUNA REPORTS.
;
DATA HTP1; INFILE OUT1;
*READ DATA COLLECTED FROM HAWAIIAN TUNA PACKERS (ON TAPE).
;
INPUT BOAT 3-4 DAY 5-6 MONTH 7-8 YEAR 9-10 LG 16-20 MED 21-25
SMED 26-30 SML 31-35 XSML 36-40;
*PROCEDURE TO EXCLUDE UFA BOAT LANDINGS.
;
IF BOAT NE 0 AND BOAT NE . AND BOAT NE 34 AND BOAT NE 51 AND
BOAT NE 62;
IF MONTH NE . AND YEAR NE .;
YRMTHTDAY=10000*YEAR+100*MONTH+DAY;
IF BOAT=41 AND YRMTHTDAY GE 790821 THEN DELETE;
IF BOAT=72 AND YRMTHTDAY GE 791006 THEN DELETE;
IF LG=. THEN LG=0;
IF MED=. THEN MED=0;
IF SMED=. THEN SMED=0;
IF SML=. THEN SML=0;
IF XSML=. THEN XSML=0;
*CALCULATE TOTAL LANDINGS.
;
HCATLB=LG+MED+SMED+SML+XSML;
*CREATE MONTHLY SUMMARY.
;
PROC SORT DATA=HTP1; BY YEAR MONTH;
PROC MEANS SUM DATA=HTP1 NOPRINT; VAR HCATLB; BY YEAR MONTH;
OUTPUT OUT=HTP2 SUM=HCATLB;
*READ DATA FROM HDAR (ON TAPE).
;
DATA FG1; INFILE OUT2;
INPUT MONTH 1-2 YEAR 3-4 SPECIES 5-9 FCATLB 10-12;
*LIMIT TO SKIPJACK TUNA.
;
IF SPECIES=1001;
IF FCATLB=. THEN FCATLB=0;
*CREATE MONTHLY SUMMARY.
;
PROC SORT DATA=FG1; BY YEAR MONTH;
PROC MEANS SUM DATA=FG1 NOPRINT; VAR FCATLB; BY YEAR MONTH;
OUTPUT OUT=FG2 SUM=FCATLB;
PROC SORT DATA=HTP2; BY YEAR MONTH;
PROC SORT DATA=FG2; BY YEAR MONTH;
*MERGE TWO PRIOR MONTHLY SUMMARIES.
;
DATA HTPFG1; MERGE HTP2 FG2; BY YEAR MONTH;

```


Appendix III Computer Program 1.--Continued.

```

*CREATE DUMMY VARIABLES FOR MONTH.
;
IF MONTH=1 THEN M1=1;ELSE M1=0;
IF MONTH=2 THEN M2=1;ELSE M2=0;
IF MONTH=3 THEN M3=1;ELSE M3=0;
IF MONTH=4 THEN M4=1;ELSE M4=0;
IF MONTH=5 THEN M5=1;ELSE M5=0;
IF MONTH=6 THEN M6=1;ELSE M6=0;
IF MONTH=7 THEN M7=1;ELSE M7=0;
IF MONTH=8 THEN M8=1;ELSE M8=0;
IF MONTH=9 THEN M9=1;ELSE M9=0;
IF MONTH=10 THEN M10=1;ELSE M10=0;
IF MONTH=11 THEN M11=1;ELSE M11=0;
PROC SORT DATA=HTPFG1;BY MONTH;
*CREATE AVERAGE LANDINGS FOR EACH MONTH OVER ALL YEARS.
;
PROC MEANS MEAN DATA=HTPFG1 NOPRINT;VAR HCATLB FCATLB;
BY MONTH;OUTPUT OUT=HTPFG2 MEAN=AVHCATLB AVFCATLB;
PROC SORT DATA=HTPFG1;BY MONTH;
PROC SORT DATA=HTPFG2;BY MONTH;
*MERGE MONTHLY SUMMARY AND AVERAGE LANDINGS VALUES.
;
DATA HTPFG3;MERGE HTPFG1 HTPFG2;BY MONTH;
PROC SORT DATA=HTPFG3;BY YEAR MONTH;
DATA;SET HTPFG3;
*PRINT FINAL DATA SET.
;
FILE PRINT;
PUT YEAR 1-2 MONTH 3-4 M1 5-6 M2 7-8 M3 9-10 M4 11-12 M5 13-14
M6 15-16 M7 17-18 M8 19-20 M9 21-22 M10 23-24 M11 25-26 HCATLB 31-40
FCATLB 41-50 AVHCATLB 51-60 AVFCATLB 61-70;
*SAVE FINAL DATA SET.
;
FILE SAVE;
PUT YEAR 1-2 MONTH 3-4 M1 5-6 M2 7-8 M3 9-10 M4 11-12 M5 13-14
M6 15-16 M7 17-18 M8 19-20 M9 21-22 M10 23-24 M11 25-26 HCATLB 31-40
FCATLB 41-50 AVHCATLB 51-60 AVFCATLB 61-70;
*CALCULATE DATA NEEDED FOR UPDATING TABLE 1.
;
DATA HTPFG4;SET HTPFG3;
AMFCATMT=.0004536*FCATLB;AMFCATLB=FCATLB;
KEEP MONTH AMFCATMT AMFCATLB;
PROC SORT DATA=HTPFG4;BY MONTH;
PROC MEANS MEAN DATA=HTPFG4;BY MONTH;
//OUT1 DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(1,SL,,IN),DSN=CD361964
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(2,SL,,IN),DSN=CD361965
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(3,SL,,IN),DSN=CD361966
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(4,SL,,IN),DSN=CD361967
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),

```


Appendix III Computer Program 1.--Continued.

```

// LABEL=(5,SL,,IN),DSN=CD361968
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(6,SL,,IN),DSN=CD361969
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(7,SL,,IN),DSN=CD361970
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(8,SL,,IN),DSN=CD361971
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(9,SL,,IN),DSN=CD361972
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(10,SL,,IN),DSN=CD361973
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(11,SL,,IN),DSN=CD361974
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(12,SL,,IN),DSN=CD361975
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(13,SL,,IN),DSN=CD361976
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(14,SL,,IN),DSN=CD361977
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(15,SL,,IN),DSN=CD361978
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21811,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=65,BLKSIZE=6500,DEN=3),
// LABEL=(16,SL,,IN),DSN=CD361979
//OUT2 DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(16,SL,,IN),DSN=FG1964
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(17,SL,,IN),DSN=FG1965
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(18,SL,,IN),DSN=FG1966
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(19,SL,,IN),DSN=FG1967
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(20,SL,,IN),DSN=FG1968
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(21,SL,,IN),DSN=FG1969
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(22,SL,,IN),DSN=FG1970
// DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(23,SL,,IN),DSN=FG1971

```

Appendix III Computer Program 1.--Continued.

```

//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(24,SL,,IN),DSN=FG1972
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(25,SL,,IN),DSN=FG1973
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(26,SL,,IN),DSN=FG1974
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(27,SL,,IN),DSN=FG1975
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(28,SL,,IN),DSN=FG1976
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(29,SL,,IN),DSN=FG1977
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(30,SL,,IN),DSN=FG1978
//          DD UNIT=(XTRK,,DEFER),VOL=SER=X21861,DISP=(OLD,PASS),
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=8000,DEN=3),
// LABEL=(31,SL,,IN),DSN=FG1979
/*
//

```

Appendix III

Computer Program 2

```

//HTPFG JOB (1078,3M,5K1,187F), 'GARY KAMER', REGION=500K
// EXEC SHAZAM
//DATA DD DSN=T010780.HTPFG,DISP=SHR
* THIS COMPUTER PROGRAM WAS WRITTEN BY GARY KAMER, STATISTICIAN FOR
* THE NATIONAL MARINE FISHERIES SERVICE, SOUTHWEST FISHERIES CENTER,
* HONOLULU LABORATORY. THIS PARTICULAR FORM OF THIS PROGRAM WAS
* COMPLETED ON 10/18/82 AND MAKES USE OF THE SHAZAM ECONOMETRICS
* PACKAGE IN PERFORMING REGRESSION ANALYSIS.
SOLOMON 15 192 STATEWIDE SKIPJACK TUNA ESTIMATIONS
* REQUEST CROSS-PRODUCT, CORRELATION, AND CO-VARIANCE MATRICES AND
* REQUEST DOUBLE PRECISION.
10 CP CR CV DP
* NAME VARIABLES.
NAME 1 JANUARY 2 FEBRUARY 3 MARCH 4 APRIL 5 MAY 6 JUNE 7 JULY 8 AUGUST
NAME 9 SEPTEMBER 10 OCTOBER 11 NOVEMBER 12 HTPCATCH 13 FGCATCH
NAME 14 AVHCATLB 15 AVFCATLB 16 ADHCATLB 17 ADFCATLB 18 ONSEASON
* CREATE NEW VARIABLES FOR USE IN REGRESSION.
GENR X16=X12-X14
GENR X17=X13-X15
GENR X18=X6+X7+X8+X9
* READ DATA FROM DSN=T010780.HTPFG.
DATA FILE(4X,11F2.0,4X,4F10.0)
* PERFORM REGRESSIONS.
OLS 13 12 1 2 3 4 5 6 7 8 9 10 11/FC MAX
OLS 13 12 18/FC MAX
AUTO 13 12 18/FC MAX UT
MERCURY
/*
//

```

Appendix IV

Data Set Name is T010780.HTPFG

<u>Variable name</u>	<u>Variable description</u>	<u>Column (right-justified)</u>
Year	Year of catch	1-2
Month	Month of catch	3-4
M1	Dummy variable--1 if month is January, 0 otherwise	5-6
M2	Dummy variable--1 if month is February, 0 otherwise	7-8
M3	Dummy variable--1 if month is March, 0 otherwise	9-10
M4	Dummy variable--1 if month is April, 0 otherwise	11-12
M5	Dummy variable--1 if month is May, 0 otherwise	13-14
M6	Dummy variable--1 if month is June, 0 otherwise	15-16
M7	Dummy variable--1 if month is July, 0 otherwise	17-18
M8	Dummy variable--1 if month is August, 0 otherwise	19-20
M9	Dummy variable--1 if month is September, 0 otherwise	21-22
M10	Dummy variable--1 if month is October, 0 otherwise	23-24
M11	Dummy variable--1 if month is November, 0 otherwise	25-26
HCATLB	Monthly TBOC vessel landings in pounds	31-40
FCATLB	Monthly catch in pounds as reported to the HDAR	41-50
AVHCATLB	Average TBOC vessel landings in pounds over all years for that month	51-60
AVFCATLB	Average catch in pounds over all years for that month as reported to the HDAR	61-70

82-23C



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
Honolulu, Hawaii 96812

FACTORS AFFECTING THE GROWTH AND SURVIVAL OF SKIPJACK TUNA,
KATSUWONUS PELAMIS, LARVAE REARED IN THE LABORATORY

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Sharon D. Hendrix
Consultant

Final contract report to the National Marine Fisheries Service,
Southwest Fisheries Center, Honolulu Laboratory
(Purchase Order No. 81-ABA-492)

January 1982

NOT FOR PUBLICATION

This report is used to insure prompt dissemination of preliminary results, interim reports, and special studies to the scientific community. Contact the author if you wish to cite or reproduce this material.

PREFACE

This report was prepared under contract (Purchase Order No. 81-ABA-492) by Sharon D. Hendrix, graduate student, University of Hawaii. The contract objectives were to collect and analyze data on the effects of various diets and rearing conditions on growth and survival of skipjack tuna, Katsuwonus pelamis, larvae reared under laboratory conditions. These data will provide information and insight on the early life history of this commercially valuable species. The data will also provide a guide for future studies such as those designed to measure the effects of normal environmental fluctuations and pollutants on survival and growth of this fish species' larvae in the wild. Since the report has been prepared under contract, the statements, findings, conclusions, and recommendations herein are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

Richard W. Brill
Fishery Biologist

December 17, 1982

INTRODUCTION

Skipjack tuna, Katsuwonus pelamis, represent an important commercial fishery resource, yet little is known about their early life history. An understanding of the mechanisms affecting mortality of early life stages is important for the management of the skipjack tuna fishery. Mortality rates during early life stages are influenced by environmental factors which in turn effect future recruitment to commercial fisheries.

Rearing skipjack tuna larvae in controlled laboratory conditions provides information concerning the early life history of skipjack tuna that is otherwise difficult if not impossible to acquire. The objective of this study is to examine the factors that affect the growth and survival of skipjack tuna larvae reared in the laboratory.

MATERIALS AND METHODS

Fertilized skipjack tuna eggs were obtained by stress-induced spawning of captive adult skipjack tuna at the National Marine Fisheries Service's Kewalo Research Facility (Kaya et al., in press). The fertilized eggs were stocked in rearing tanks at a density of 20 eggs/l. The rearing tanks were cylindrical, black fiberglass tanks (4 ft in diameter, 16 in. deep) immersed in temperature controlled water baths. Fluorescent lamps suspended over the tanks provided illumination.

The tanks were initially filled with 200 l of filtered seawater, however, additions of algae and food organisms increased the volume to as much as 300 l. The tank volume was maintained between 200 and 300 l by siphoning water from the bottom of the tanks periodically, which also

served to keep the tanks clean. Algae was added to the tanks prior to egg hatching; food organisms were added the second day after hatching. Mild aeration was started in the rearing tanks 3-4 days after hatching.

Larvae were initially fed laboratory cultured rotifers, Brachionus plicatilis, with daily additions of 4-8 l of algae (Tetraselmis sp. and Isochrysis sp.) to provide food for the rotifers. When available, cultured copepods (Tigriopus sp. and Euterpina acutifrons), Artemia nauplii or collected zooplankton were obtained and fed to 4-5 day old larvae.

Growth rates were determined by sampling 10 or more larvae periodically, however, as the numbers of larvae in a tank population declined, fewer larvae were sampled. Length (SL), eye diameter and body depth were measured while larvae were alive, using a calibrated micrometer mounted in a dissecting microscope.

Behavioral observations were made as frequently as possible, noting feeding behavior and swimming speed. Swimming speeds were determined by tracing a larva's swimming path on a piece of clear plastic using a pen mounted in a cross-hair device. The path distance was determined using a map reader. Ten observations were made daily, with observation times between 10 and 67 sec.

Attempts to rear skipjack tuna larvae from hatching through metamorphosis during June through August 1980 resulted in limited success, with larvae surviving up to 12 days after hatching. All 1980 rearing experiments were conducted at 24° C, using a 12 h day/12 h night light regime, and prey concentrations of 10-20/ml rotifers with additions of collected zooplankton at 1-2/ml when available.

In 1981, detailed studies were undertaken to determine the causes of the high larval mortalities observed in 1980. These studies examined several factors that affected growth and survival of skipjack tuna larvae, including temperature, light regime, dissolved oxygen, nutrient concentration, and water quality. Experiments were conducted for each of the spawnings as follows:

		Tank A	Tank B	Tank C
1st spawn	Temperature:	26° C	24° C	24° C
	Light:	12 h D/12 N	14 h D/10 N	24 h D/0 N
	Prey:	~15/ml <u>Brachionus</u> , ~1/ml <u>Artemia</u> nauplii and <u>Tigriopus</u> sp.		
2d spawn	Temperature:	24° C	24° C	22° C
	Light:	14 h D/10 N	14 h D/10 N	12 h D/12 N
	Prey:	~15/ml <u>Brachionus</u> , ~1/ml <u>Euterpina acutifrons</u>		
	Extra			
	procedures:	Monitor dissolved oxygen, examine larvae for bacterial fouling.		
3d spawn	Temperature:	24° C	24° C	24° C
	Light:	All tanks 14 h D/ 10 h N		
	Prey:	~15/ml <u>Brachionus</u> for all tanks.		
	Extra			
	procedures:	Monitor dissolved oxygen, mild aeration used if D.O. <80% saturation. Nutrients monitored in tanks A and B only. ~5,000 eggs shipped to NMFS La Jolla for rearing.		
4th spawn	Temperature:	All tanks at 24° C.		
	Light:	All tanks 14 hr D/10 hr N		
	Prey:	~15/ml <u>Brachionus</u> , 0.5-2/ml <u>E. acutifrons</u>		
	Extra			
	procedures:	Monitor dissolved oxygen, mild aeration used if D.O. <80% saturation. Nutrients monitored in tanks A and B. High algal concentration maintained in tank A. ~10,000 eggs shipped to NMFS La Jolla for rearing.		

Dissolved oxygen was monitored with an oxygen probe and YSI oxygen meter. Water samples were analyzed for phosphate, nitrate and nitrite, and ammonia by University of Hawaii HIMB Analytical Services. Eggs were shipped to NMFS La Jolla Laboratory in plastic bags and containers filled with autoclaved seawater. Larvae were reared at La Jolla using similar materials and methods. The purpose of the co-rearing was to determine if the difference in water quality at the two laboratories affected larval growth and survival.

RESULTS

General observations

Skipjack tuna eggs obtained from stress-induced spawnings were transparent and spherical, ranging from 0.9 to 0.96 mm in diameter with a single oil globule averaging 0.24 mm in diameter. Eggs hatched in 31-32 h at 26° C, and in 34-36 h at 24° C.

Larvae had an average length of 2.94 mm at hatching with a yolk sac averaging 0.73 mm long by 0.43 mm wide. The second day after hatching, larvae had pigmented eyes, functional jaws and remnants of the oil globule. At this time larvae had not started to feed but were exhibiting feeding and searching behavior. Larvae were actively feeding by the third day after hatching, larvae that did not initiate feeding died between 3 and 7 days. At day 3, many larvae were observed to have jaw abnormalities which apparently prevented them from capturing and ingesting sufficient quantities of food. The percentage of deformed larvae varied with different spawnings, in most groups 20-30% of day 3 larvae had deformed jaws.

Spination of the head region and jaw dentition was observed in 8-10 day old larvae. Larvae were essentially transparent, with pigmentation concentrated in the head and stomach regions and scattered along the trunk.

Survival

Most of the skipjack tuna larvae died by day 7, with 2 groups of larvae surviving to day 12 (Table 1). Heaviest mortalities were observed on days 4 and 5, with losses of 50% or more of the tank population. Dying larvae usually swam slowly, 1-3 cm above the tank bottom, intermittently sinking in a head-down position. These larvae usually had shrunken stomachs characteristic of starvation, but were not necessarily smaller than actively feeding larvae (Table 2).

Growth

Skipjack tuna larvae grew slowly in length, with no apparent effect of temperature on growth (Table 1). The 24-h day light regime resulted in total mortality by day 3, therefore the 14 h D/10 h N light regime was used in most rearing trials since it best approximated normal light conditions for that time of year.

Two groups of larvae (July 16, 1930 and May 31, 1931 spawns) exhibited significant growth and survival (Table 1). Statistical comparison of the two growth equations resulted in no significant difference between slopes and intercepts ($P < 0.05$, ANOVA, Sokal and Rohlf, 1969). Length data obtained from these two rearing groups were pooled and the results shown in Figure 1. All other rearing experiments resulted in insignificant growth (Table 1).

Swimming and feeding behavior

Skipjack tuna larvae swam at an average speed of 0.45 cm/sec (~1.2 body lengths/sec) from day 2 to 10, averaging 1.64 (S.D. = 0.836) feeding attacks per minute.

Larvae continually searched the water column for prey. After selecting a prey, a larva would then stop and monitor it's prey while flexing the tail back into a tightly curved position. The strike involved a quick forward movement achieved by releasing the tail from the curved position and opening the mouth so that the prey was engulfed. This type of feeding behavior is similar to that seen in Pacific mackerel (Hunter and Kimbrell, 1930). Usually larvae would attack the same prey several times until the prey was ingested if the initial attack was unsuccessful.

Larvae fed mostly on rotifers, although with a jaw width of about 0.30 mm at first feeding, larvae were capable of ingesting much larger prey. Large prey, such as copepods or Artemia nauplii, were usually avoided by 5-7 day old larvae. Eight-ten day old larvae occasionally chased and attacked larger prey, however, only a few successful strikes were observed. Observations were made of 8-10 day old larvae seizing adult copepods and Artemia nauplii and then releasing their prey without subsequent pursuit. Many 8-10 day old larvae were seen along the side walls of the rearing tanks, apparently feeding on copepodites and copepod nauplii.

Water quality

Dissolved oxygen remained above 80% saturation before food organisms were added to the rearing tanks. After food organisms were added, the daytime dissolved oxygen levels remained above 80% saturation but pre-dawn

levels dropped to 70% saturation or lower. The nighttime dissolved oxygen decrease was prevented by starting mild aeration on day 3, preventing pre-dawn dissolved oxygen levels from dropping below 85% saturation.

Buildup of nutrients (phosphate, nitrate and nitrite, and ammonia) occurred in rearing tanks as waste products from the larvae and food organisms accumulated (Table 3). Average ammonia levels increased in the tanks fivefold from the time of hatching (156.8 ppb) to day 5 (800 ppb) (Table 3). Average nitrate and nitrite levels increased sixfold in the same time period from 39.6 to 249.2 ppb, while phosphate levels increased fourfold from 32.2 to 126.2 ppb (Table 3).

Of the two groups of eggs shipped to La Jolla Laboratory, the Aug. 4 1981 spawn group survived the longest with larvae reared to day 4. Larvae from the same spawn reared at Kewalo laboratory survived to day 5. Since no significant increase in survival was obtained when eggs were reared in La Jolla, water quality at Kewalo laboratory may not be the sole cause for high larval mortality.

DISCUSSION AND RECOMMENDATION

The egg and early larval stages of skipjack tuna are similar to early stages of other scombrids, such as the yellowfin tuna, Thunnus albacares (Harada et al., 1971; Inoue et al., 1974a; Harada et al., 1980), the bigeye tuna, T. obesus (Houde and Richards, 1969), the frigate mackerel, Auxis rochei (Inoue et al., 1974a), A. tapeinosoma (Harada et al., 1973a), A. thazard (Harada et al., 1973b), the Pacific mackerel, Scomber japonicus (Hunter and Kimbrell, 1980), and several other scombrid species (Mayo, 1973). All of these species have slow, linear growth from hatching to 8 or 10 days and are about the same size at hatching.

Although the larvae of several scombrid species have been reared beyond metamorphosis, larvae of skipjack tuna have never been reared beyond 12 days after hatching. In an attempt to culture larval skipjack tuna, Japanese scientists obtained eggs from a ripe skipjack tuna female caught in a purse seine and dry fertilized the eggs (Inoue et al., 1974b; Ueyanagi et al., 1974). The subsequent larvae suffered substantial mortalities, with all larvae dying by the fifth day after hatching (Inoue et al., 1974b; Ueyanagi et al., 1974). Mayo (1973) attempted to rear skipjack tuna larvae from eggs caught in a plankton net. These larvae survived to 6.5 days after hatching, reaching a maximum length of 4.17 mm.

Skipjack tuna larvae are proving to be more difficult to culture than other scombrid larvae. The reasons are not obvious for the marked survival and growth of the July 16, 1980 and May 31, 1981 spawns, or for the high mortalities observed in the other groups. The stress-induced spawning method may cause adult skipjack tuna to hydrate and ovulate less than full-term eggs which would result in eggs with less than normal quantities of yolk (Hunter, pers. commun.). Low yolk reserves may result in energy deficiencies that could affect development as well as growth and survival of larvae.

The adults used for stress-induced spawnings are usually of small size, perhaps in the first season of spawning activity, which may also result in the spawning of eggs having low quantities of yolk or spawns with a high percentage of nonviable eggs. However, the stress-induced spawnings yielded normal appearing eggs, with high hatching rates, therefore not all of the problems associated with culturing larvae can be attributed to the spawning method.

If stress-induced spawning produces eggs with low quantities of yolk, it should be possible to compensate for energy deficiencies by feeding larvae prey of high caloric content. Rotifers have a caloric content of 8.54×10^{-4} calories/individual (Theilacker and McMaster, 1971), and copepod nauplii have a caloric content of 6.8×10^{-3} calories/individual (Laurence, 1977). Therefore if a larva ingested a copepod nauplius instead of a rotifer, it could obtain nearly an order of magnitude more calories. Rotifers may not supply adequate energy for skipjack tuna larval growth and survival, yet the rotifer appears to be adequate for first feeding larvae of other scombrids (Inoue et al., 1974a; Hunter and Kimbrell, 1980).

At sea, skipjack tuna larvae have a noticeably different diet than other tunas, skipjack tuna larvae prey predominantly on Appendicularians (Uotani et al., 1981). Perhaps appendicularians have a high caloric content and are necessary in the diet of skipjack tuna larvae for optimal growth and survival.

Water quality, especially the accumulation of ammonia, may affect the successful culture of skipjack tuna larvae. Unionized ammonia is toxic to many species of marine fish larvae at concentrations as low as 300 ppb (Brownell, 1980). Skipjack tuna larvae probably do not encounter ammonia concentrations of 300 ppb or more at sea, which suggests that they may be particularly sensitive to low levels of ammonia.

It is doubtful that water quality alone is causing the high mortalities observed in rearing skipjack tuna larvae, since attempts have been made by several scientists at different laboratories to rear these larvae. It seems that a combination of several factors--diet, water

quality, and egg quality are affecting successful rearing of skipjack tuna larvae in the laboratory. I recommend continuing the rearing effort with the following studies:

1. Eliminate water quality as a causative agent for larval mortality. This can be done by regular monitoring of nutrients and water exchange in the rearing tanks.
2. Establish a criterion for egg quality, egg diameter would probably be a good criterion. It would be simple to compare the results of rearing experiments of spawnings from different adult females with different mean egg diameters. Perhaps larvae reared from spawns of large eggs (0.95-1.0 mm diameter) would grow and survive better than larvae reared from spawns of small eggs (0.90-0.94 mm diameter).
3. Spawn larger fish, using larger sized females and males that are more mature than adults used in past spawnings.
4. Determine the effect of rearing larvae on various prey types and perform stomach analysis of locally caught larvae to determine what types of prey are ingested.
5. Study the energetics of growth of skipjack tuna larvae, comparing various stages of growth and conditions of larvae. An energetic study of a series of larvae reared from spawns of different egg sizes would indicate the relationship between energetic content and egg quality and the effect on larval growth and survival.

Acknowledgments

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LITERATURE CITED

- Brownell, C. L. 1980. Water quality requirements for first-feeding in marine fish larvae. 1. Ammonia, nitrite, and nitrate. J. Exp. Mar. Biol. Ecol. 44:269-283.
- Harada, T., K. Mizuno, O. Murata, S. Miyashita, and H. Furutani. 1971. On the artificial fertilization and rearing of larvae in yellowfin tuna. [In Jpn. with Engl. abstr.] Mem. Fac. Agric., Kinki Univ. 4:145-151.
- Harada, T., O. Murata, and H. Furutani. 1973a. On the artificial fertilization and rearing of larvae in marusoda, Auxis tapeinosoma. [In Jpn. with Engl. Abstr.] Mem. Fac. Agric., Kinki Univ. 6:113-116.
- Harada, T., O. Murata, and S. Miyashita. 1973b. On the artificial fertilization and rearing of larvae in hirasoda, Auxis thazard. [In Jpn with Engl. Abstr.] Mem. Fac. Agric., Kinki Univ. 6:109-112.
- Harada, T., O. Murata, and S. Oda. 1980. Rearing of and morphological changes in larvae and juveniles of yellowfin tuna. [In Jpn.] Bull. Fac. Agric., Kinki Univ. 13:33-35. [Engl. transl. by T. Otsu, 1980, 3 p., Transl. No. 51; available Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812].
- Houde, E.D. and W. J. Richards. 1969. Rearing larval tunas in the laboratory. U.S. Dept. of Commerce, Commer. Fish. Rev. 31:32-34.
- Hunter, J.R. and C. M. Kimbrell. 1980. Early life history of Pacific mackerel, Scomber japonicus. Fish. Bull., U.S. 78:89-101.
- Inoue, M., Y. Iwasaki, M. Aoki, K. Tutumi, and H. Nagaoka. 1974a. Some notes on the artificial fertilization and rearing of larvae in Frigate mackerel and Yellowfin tuna, cultured with seawater-acclimatized Chlorella as a basic diet. [In Jpn. with Engl. abstr.] J. Fac. Mar. Sci. Tech., Tokai Univ. 3:27-36.

- Inoue, M., K. Tutumi, H. Nagaoka, and T. Nagata. 1974b. Some notes on the artificial fertilization and rearing of larvae in the skipjack tuna. [In Jpn. with Engl. abstr.] J. Fac. Mar. Sci. Tech., Tokai Univ. 3:37-42.
- Kaya, C.M., A. Dizon, S. Hendrix, T. Kazama, and M. Queenth. In press. Stress-induced egg maturation and ovulation of skipjack tuna, Katsuwonus pelamis. Fish. Bull., U.S.
- Laurence, G.C. 1977. A bioenergetic model for the analysis of feeding and survival potential of winter flounder, Pseudopleuronectes americanus, larvae during the period from hatching to metamorphosis. Fish. Bull., U.S. 75:529-546.
- Mayo, C.A. 1973. Rearing, growth and development of the eggs and larvae of seven scombrid fishes from the straits of Florida. Ph.D. Thesis, Univ. Miami, 127 p.
- Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Co., San Francisco. 776 p.
- Theilacker, G.W. and M.F. McMaster. 1971. Mass culture of the rotifer, Brachionus plicatilis and its evaluation as a food for larval anchovies. Mar. Biol. 10:183-188.
- Ueyanagi, S., Y. Nishikawa, and T. Matsuoka. 1974. Artificial fertilization and larval development of skipjack tuna, Katsuwonus pelamis. [In Jpn. with Engl. abstr.] Bull. Far Seas Fish. Res. Lab. 10:179-188.
- Uotani, I., K. Matsuzaki, Y. Makino, K. Noda, O. Inamura, and M. Horikawa. 1981. Food habits of larvae of tunas and their related species in the area northwest of Australia. [In Jpn. with Engl. abstr.] Bull. Jap. Soc. Sci. Fish. 47:1165-1172.

Age (days)	29 June 1980		29 June 1980		16 July 1980		21 July 1980		1 August 1980		1 August 1980	
	Tank A	SD	Tank C	SD	Tank B	SD	Tank C	SD	Tank B	SD	Tank C	SD
0	12 2.53 0.17		12 2.71 0.17		24.54°C		24.60°C		24.48°C		24.67°C	
1	12 3.43 0.22		8 3.33 0.09		15 3.46 0.09		11 3.64 0.10		15 3.44 0.15		15 3.31 0.15	
2	12 3.56 0.10				20 3.45 0.10							
3												
4	10 3.67 0.09		2 3.68		15 3.80 0.24		15 3.79 0.27		15 3.39 0.16		15 3.35 0.12	
5												
6					15 4.10 0.22		11 3.72 0.19					
7							15 3.87 0.20					
8					2 4.12		3 3.86 0.09					
9												
10					1 4.46							
11					1 4.37							

Age (days)	31 May 1981		31 May 1981		25 June 1981		25 June 1981		28 July 1981		4 August 1981	
	Tank A	SD	Tank B	SD	Tank A	SD	Tank B	SD	Tank B	SD	Tank A	SD
0	12 3.57 0.33		24.32°C		24.13°C		23.63°C		24.07°C		24.67°C	
1	15 3.58 0.12		n x	SD	n x	SD	n x	SD	n x	SD	n x	SD
2			15 3.44 0.22		15 3.53 0.10		15 3.55 0.07		15 2.83 0.14		15 3.54 0.09	
3	15 3.67 0.07		15 3.65 0.14		15 3.58 0.08		15 3.61 0.13		15 3.12 0.12		15 3.40 0.10	
4	15 3.59 0.18		15 3.78 0.17		10 3.54 0.16		10 3.60 0.06					
5			15 3.74 0.17		10 3.66 0.24		10 3.60 0.09					
6			15 3.76 0.14		5 3.58 0.21		10 3.64 0.17					
7					2 3.75		5 3.64 0.11					
8							6 3.70 0.30					
9							1 3.90					
10												
11												

13

Age (days)	4 August 1981		4 August 1981		4 August 1981	
	Tank B	SD	Tank C	SD	Tank C	SD
0	15 3.08 0.15		26.04°C			
1	15 3.58 0.07		n x	SD		
2	15 3.59 0.11		15 3.53 0.11			
3	15 3.71 0.11		15 3.50 0.09			
4	10 3.72 0.07		15 3.57 0.08			
5	15 3.63 0.12					

1 3.80

Table 2. Comparison of lengths of skipjack tuna larvae that are dying (near the bottom) with larvae that are normal (feeding near the surface). Significance levels of statistical analysis (ANOVA, Sokal and Rohlf, 1969) for differences in length are given with the mean lengths (mm) and standard deviations for each group tested. Also noted are the percentage of larvae with jaw abnormalities found in each sample.

Age (days)	Spawn date	Tank	Length (mm)		ANOVA results
			Normal larvae	Dying larvae	
4	31 May 81	B	$\bar{x}$	3.746	Significant difference in length ($P < 0.01$)
			S.D.	0.168	
			% abnormal	20%	
4	25 June 81	C	$\bar{x}$	3.595	No significant difference in length
			S.D.	0.086	
			% abnormal	not noted	
2	4 Aug. 81	B	$\bar{x}$	3.577	No significant difference in length
			S.D.	0.105	
			% abnormal	40%	
4	4 Aug. 81	B	$\bar{x}$	3.533	Significant difference in length ($P < 0.001$)
			S.D.	0.119	
			% abnormal	60%	
5	4 Aug. 81	B	$\bar{x}$	3.63	No significant difference in length
			S.D.	0.127	
			% abnormal	100%	

Table 3. Average nutrient concentrations (and standard deviations) of phosphate, nitrate + nitrite, and ammonia in ppb of water in rearing tanks A and B, 4 Aug. 1981 spawn.

Age (days)		Phosphate	Nitrate + nitrite	Ammonia
0	$\bar{x}$	32.24	39.62	156.8
	S.D.	10.52	2.376	6.534
1	$\bar{x}$	54.56	42.63	192.22
	S.D.	10.52	4.653	36.826
2	$\bar{x}$	71.61	46.62	303.31
	S.D.	0.877	2.772	58.11
3	$\bar{x}$	75.79	65.94	404.39
	S.D.	15.56	3.762	101.87
4	$\bar{x}$	92.76	124.46	610.61
	S.D.	13.72	10.64	113.24
5	$\bar{x}$	126.17	249.20	800.80
	S.D.	0	51.87	175.62

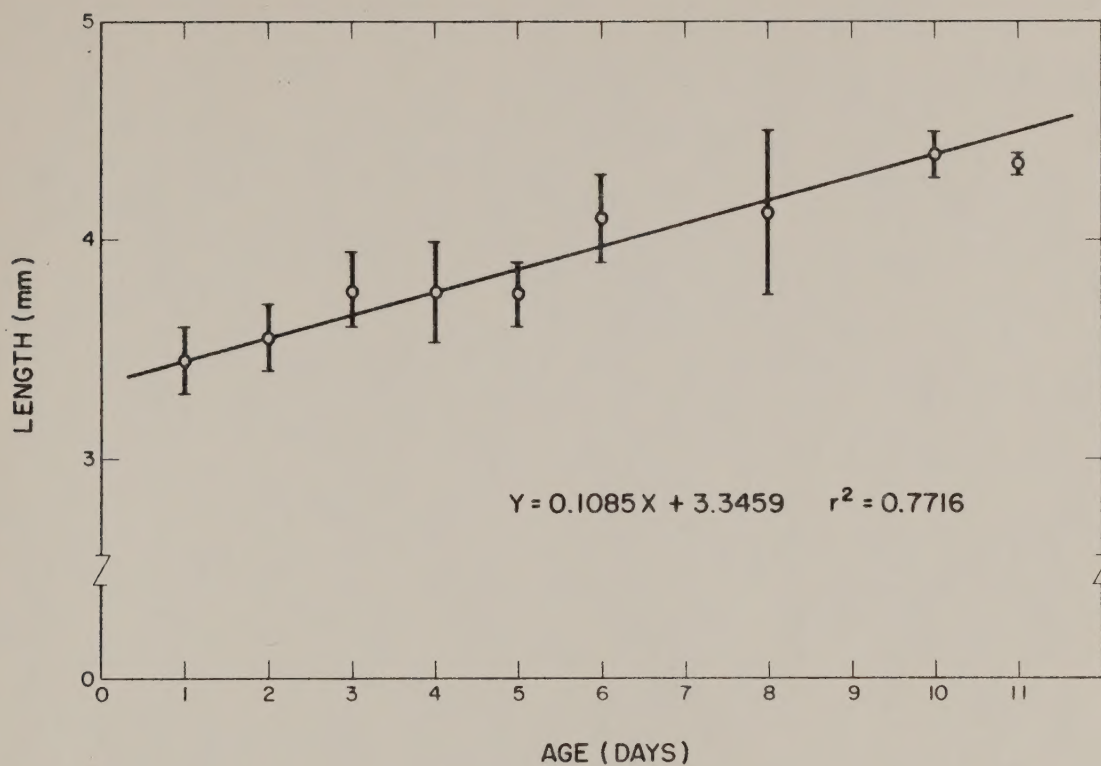


Figure 1. Growth of skipjack tuna larvae (16 July, 1980 and 31 May, 1981 spawns) to 11 days after hatching. Mean lengths $\pm$ 1 standard deviation are given for larvae from combined spawns. (Statistical analysis of separate regression lines obtained from each spawn group indicated no significant difference between slopes or intercepts ($P < 0.01$) therefore data from both spawns were combined).

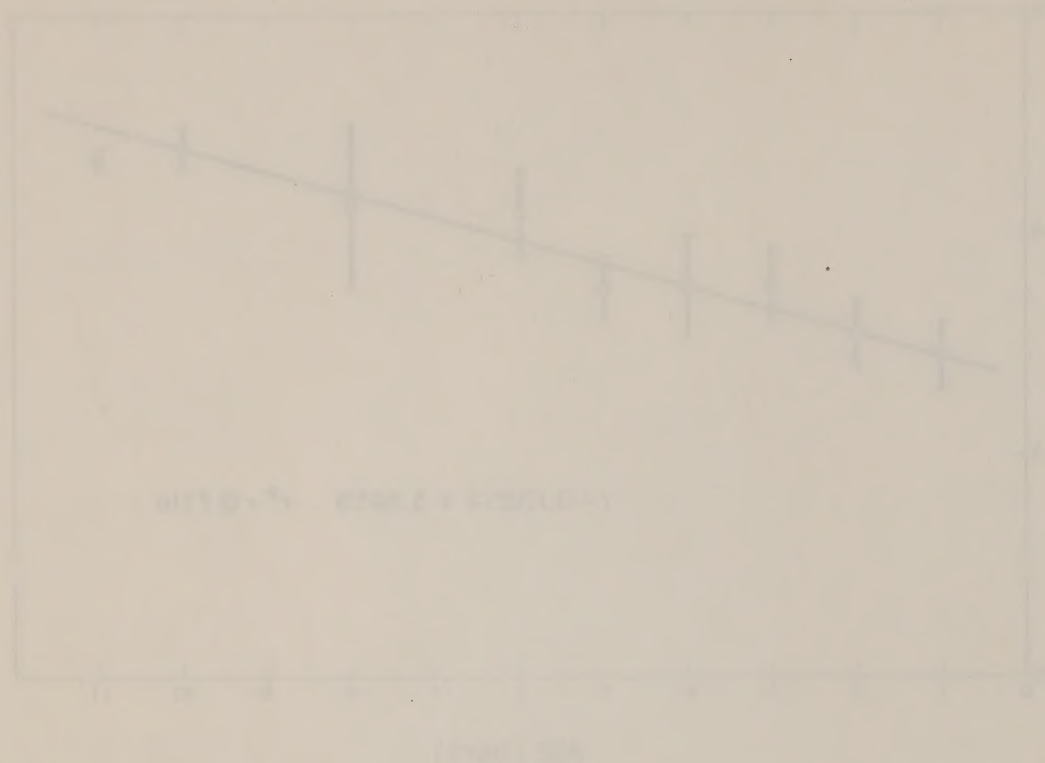


Figure 1. Growth rate of *Paralichthys lethostigma* larvae reared at different temperatures. The growth rate was determined by measuring the length of the larvae at the start and end of the experiment. The data show that the growth rate decreases as the temperature increases. The error bars represent the standard deviation of the data.

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